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The Weather Bureau desires that the MONTHLY WEATHER REVIEW shall be a medium of publication for contributions within its field, but the publication of contributions is not to be construed as official approval of the views expressed.

ECONOMIES IN PRINTING.

Contributions intended for publication in the REVIEW must in all cases conform to the regulations of the Department of Agriculture with respect to effecting economies in the public printing. The following memorandum in regard to preparing manuscripts for publication has just been issued by the Department.

It is reproduced below for the information of all concerned.

Authors will be expected to prepare their manuscripts, with the understanding that once the manuscript leaves the author's hands it is in final form and not subject to further changes of text in galley or page proof. With the adoption of this policy it will be necessary that authors consult workers on related subjects in other Bureaus before finally submitting their manuscript for publication, and all matters as to which there is difference of opinion must be settled in advance.

BACK NUMBERS OF THE REVIEW WANTED.

The Weather Bureau has not enough of the following numbers of the MONTHLY WEATHER REVIEW to meet even urgent requests for filling up files at institutions where the REVIEW is constantly being referred to. The return of any of these or of any 1919 or 1920 issues, especially November, 1919, will be greatly appreciated. An addressed franked slip may be had on application to the Chief, U. S. Weather Bureau, Washington, D. C.

1914: January, February, March, April, September, October, December.
1915: May, June, July, August.
1916: January, August.
1917: June.
1918: February, September.
1919: Any issue, especially November.
1920: Any issue, especially January.
SUPPLEMENT, No. 3.

CLIMATE AND ALFALFA SEED.

Weather records have just been put to a splendid use by the Utah State Farm Bureau, which is handling the alfalfa seed pool for the State. The following is a portion of a report reprinted from the *Salt Lake City Telegram* of December 27, 1920, to show the bearing of climatic data on the sale of the seed:

The Utah State Farm Bureau in offering the Utah alfalfa seed crop for sale through Eastern State farm bureaus was informed by the Michigan State Farm Bureau of Lansing that "Utah seed, originating as it does mostly from more southerly climates, and not having the severe winters that we have, in its present habitat, has not proven hardy enough for our conditions." In reply, comparative weather data was furnished for Deseret, Emery, and Fort Duchesne, Utah, as representing the districts from which seed was being offered. These data were compared directly with similar values for Lansing, covering the average monthly, mean maximum, mean minimum, monthly extreme highest, and lowest temperatures, and the average dates of latest killing frost in spring and the earliest in autumn, which show that the Utah seed is acclimated to somewhat more severe temperatures than those prevailing at Lansing, the Utah temperatures being higher in summer and lower in winter, with greater daily ranges and a shorter summer season between frosts.

The commercial agent for the State farm bureau writes: "Information of this kind is going to be very valuable to us. The alfalfa seed deal which we are now handling for the grower will amount to several hundred thousand dollars, and we certainly appreciate the willing spirit which you manifest in cooperating with us."—*J. Cecil Alter.*

INFLUENCE OF CLIMATE ON THE YIELD AND QUALITY OF SUGAR BEET IN CANADA.

By E. G. McDOUGALL, M. A., DOMINION METEOROLOGICAL SERVICE, TORONTO.

[Abstracted from *Monthly Bull. of the Dominion Bureau of Statistics*, vol. 13, No. 146, Oct., 1920, Ottawa.]

With the view of determining the suitability of soil and climatic conditions in various parts of the Dominion for the growth of sugar beets, Dr. Frank T. Shutt, dominion chemist and assistant director of experimental farms, inaugurated in 1902 an investigation of the subject, which included experimental plots at various points in the country. The reports of the division of chemistry, issued annually, contain the details and data collected in this work, which is now in its eighteenth year. The data as published include the percentage of sugar in the juice, the percentage of solids in the juice, and the coefficient of purity. The yield per acre is estimated, and owing to the small size of the plots, these data are of somewhat doubtful accuracy.

The author has correlated the experimental data with the weather factors during the growing season. The correlations between the percentage of sugar and the weather factors are decidedly small, but the coefficient of purity (the percentage of sugar in the dissolved solids) is more significantly related to weather conditions, having its highest correlation (a positive one) with the mean minimum temperature for the season. The yield shows a positive relation with both maximum and minimum temperatures, and most significantly with the mean temperature for the season. It has a high positive correlation with the relative humidity, and an unexpected low one with the rainfall.

The studies as published prompt the following conclusions: The yield is closely related to the mean temperature, and, in a less degree, to the mean relative humidity of the growing season. Conditions are favorable when the mean temperature exceeds 60° F. and the relative humidity exceeds 80 per cent. They are unfavorable when the temperature falls below 55° and the relative humidity below 70 per cent. Within ordinary limits the yield is not very greatly affected by the rainfall, provided the crop is thoroughly cultivated. In semiarid regions irrigation increases the yield without impairing the quality. The quality of the beets depends chiefly on the night temperatures; the sugar content and purity decline when the mean temperature for the season falls below 45°.—*J. B. K.*

CRITICAL PERIODS OF RICE.

By B. MARCARELL.

[Abstracted from *International Review of the Science and Practice of Agriculture*, March, 1919; International Institute of Agriculture, Rome.]

In rice growing the two most important climatic factors are heat and light. The critical periods of rice are those during which it has an absolute need of a certain minimum quantity of heat and light. If these minimums are not available at these periods the yield will be small even though the temperature be high and the days sunny throughout the rest of the vegetative period. In northern Italy, the critical periods are during tillering (more especially when the rice turns yellow before tillering) and during the formation of the panicle. If at these two stages the heat is not sufficient to keep the atmosphere of the rice field at a minimum temperature of 13° to 14° C. (55° to 57° F.) for the first stage and 15° to 16° C. (59° to 61° F.) for the second, according to the variety of rice cultivated, the yield in paddy may be partly compromised.—*J. W. S.*

CONCERNING A GRAPHICAL DEVICE FOR PRESSURE REDUCTION.

By C. Le Roy Meisinger.

[Weather Bureau, Washington, D. C., Aug. 1, 1921.]

SYNOPSIS.

This paper is essentially an expansion and elaboration of an article by Schwerdt and Loebe on a graphical solution of the hypsometric formula. The steps from the forming of a linear equation and the substitution of terms from the hypsometric equation, to the final drawing of the nomogram are traced. The device enables one to determine by means of a straight line joining two points representing known elements of the hypsometric equation, the value of a third element. These elements are: (1) Sea-level pressure, (2) pressure at some level above sea level, and (3) the mean temperature of the air column. There are tables for the construction of a chart, and a reproduction of the completed chart for reducing pressures within the lowest two kilometers of the atmosphere.

One of the principal arguments against the use of graphical methods as aids in making scientific computations is their inaccuracy, for often it is not possible, either because of the nature of the fundamental formulæ or because of the difficulty of accurately drawing the chart, to secure the desired refinement. On the other hand, a nomogram that is an accurate representation of a formula and one that possesses the merits of being correctly drawn and not too complicated, makes a direct appeal. Meteorologists, and others, who have had occasion to make pressure reductions by means of the Laplacian hypsometric formula for special conditions, or for places for which reduction tables have not been constructed, are unanimous in their expressions of opinion regarding the labor and tedium of the process. It is with special interest, therefore, that we have read the article by Hans G. Schwerdt and W. W. Loebe, entitled *Eine nomographische Tafel zur Luftdruckreduktion*,[1] wherein is presented a solution of the problem of graphical pressure reduction.

The object of these authors is to produce a graph of such simplicity that upon joining two given points with a straight line, a third point on that line will yield information regarding an unknown element. For example, if one knows the station pressure and the temperature argument at a given place, it is possible, by producing the line joining the two points which represent these two elements until it intersects a scale which represents pressure at sea level, to read off the pressure reduced to sea level directly; or one can read off directly pressures at any level in the free air, if the temperature argument and station pressure are known; or (as might occur in some studies) if the pressure is known at two levels in the atmosphere, the projected line will give the mean temperature of the air column.

The mathematical explanation of the drawing, as presented by the authors, is hardly satisfying, because it does not generalize the method sufficiently, and because it possesses so much of the Laplacian *il est facile de voir*. An attempt is made in this paper, therefore, to point out the processes which were employed by the authors and to present general formulæ for preparing the chart.

The hypsometric formula of Laplace may be stated as follows:

$$\text{Log } B - \log b - h/[18387\ (1+\alpha t)] = 0,$$

or, in a manner more convenient for our purpose,

$$\text{Log } B - \log B_0 - \log b + \log b_0 - 0.0000543h/(1+\alpha t) = 0 \quad (1)$$

in which B is sea-level pressure, b is station pressure, h the length of the air column, t the mean temperature of the air column, α a constant, 0.00367, and B_0 and b_0 two pressures which are of use in preparing the diagram and which will be discussed later, it being mathematically obvious that B_0 must equal b_0.

If we erect a set of Cartesian coordinate axes, and desire to have a straight line serve us in determining pressures, it is clear that we must have three points—(x_1, y_1) being a point on the scale representing the mean temperature of the air column; (x_2, y_2) being a point on a scale representing station pressure; and (x_3, y_3) a point on a scale representing the pressure at the reduction level. The condition that a straight line shall pass through these points is

$$\begin{vmatrix} x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \\ x_3 & y_3 & 1 \end{vmatrix} = 0$$

or,

$$x_2 - y_2 x_3/y_3 - x_1\ (1 - y_2/y_3) = 0 \quad (2)$$

It remains, now, to reconcile equations (*1*) and (*2*).

In the above paragraph specific duties were assigned to the three points—it is now necessary to assign them their positions on the chart. (x_1, y_1) is to take care of the temperature argument, and, for convenience, we will place it on the x axis. That is to say, $y_1 = 0$, and x_1 is that portion of the formula dealing with temperature, or $1/(1+\alpha t)$. Let the scale representing sea-level pressures be parallel to the x axis and some distance c below it. Thus, x_2 will care for the sea-level pressures and will be equal to $\log B - \log B_0$. The station-pressure scales are located between the two scales, $y_1 = 0$ and $y_2 = c$; and their distance from the x axis will be a function of the height of the station above sea-level. This is expressed by y_3, and from (*1*) and (*2*) it is found that

$$y_3 = y_2/(1+0.0000543h)$$
$$= c\ /(1+0.0000543h)$$

In a similar manner we find that

$$-y_2 x_3/y_3 = -\log b + \log b_0$$

or
$$x_3 = y_3(\log b - \log b_0)/c$$

Now, let us summarize the expressions for the various scales:

$$\begin{array}{l|l} x_1 = 1/(1+\alpha t) & y_1 = 0 \\ x_2 = \log B - \log B_0 & y_2 = c \\ x_3 = y_3(\log b - \log b_0)/c & y_3 = c/(1+0.0000543h) \end{array}$$

These equations give the coordinates of the three points on the straight line; but if the numerical values for the various terms were chosen at random, it might easily follow that the graph would not be usable because of the inconvenience of the scales. For instance, it is necessary to expand the horizontal scales in order to make the units large enough to read with the required precision. For that reason, the horizontal scales must be magnified by a certain factor k which may be assigned any value that may prove convenient for each of the different uses of the table. If the values of x are thus magnified, we have:

$$x_1 = k/(1+\alpha t),\ x_2 = k(\log B - \log B_0),\ \text{and}\ x_3 = ky_3(\log b - \log b_0)/c.$$

[1] *Meteorologische Zeitschrift*, May, 1921, pp. 139-142.

The authors mentioned above chose to magnify the horizontal scales by the factor 4,000 and to make the value of c, or the vertical extent of the diagram, 200 units. When they did this, they found that the distribution of the x_3 scales is better if, instead of making $x_1 = 4{,}000/(1+\alpha t)$ and $y_3 = c/(1+0.0000543h)$, the factor 10 is taken from the denominator of y_3 and placed in the denominator of x_1. This can be done, as is obvious from (*1*). With these changes effected, the values of the coordinates become:

$x_1 = -400/(1+\alpha t)$	$y_1 = 0$
$x_2 = 4{,}000 \log B - 4{,}000 \log B_0$	$y_2 = -200$
$x_3 = -20 y_3 (\log b - \log b_0)$	$y_3 = -200/(1+0.000543h)$

Now, what are to be the values of B_0 and b_0? It is clear that the more nearly perpendicular to the scales is the line on which the three points lie, the greater will be the convenience and accuracy of the chart. It is desirable, therefore, to have the middle of the temperature scale nearly above the most frequent value of sea-level pressure. If it is decided to locate the point of 0° C. above 760 mm. pressure, one may proceed as follows: If $t = 0°$ C., $x_1 = -400$. This is to be the value of x_2 also when $B = 760$ mm., hence,

$$\begin{aligned} -400 &= 4(1{,}000 \log 760 - 1{,}000 \log B_0) \\ &= 4(2880.8 - 1{,}000 \log B_0) \\ 1{,}000 \log B_0 &= 2880.8 + 100 \\ &= 2980.8 \end{aligned}$$

If the decimal is dropped, the number will be more convenient to handle and the effect on the chart will be negligible. The value of x_3 thus becomes $-0.02\, y_3\, (1{,}000 \log b - 2{,}980)$.

There is the further characteristic of this diagram that lines drawn through points of equal pressure on the various scales are *straight lines passing through the origin*, and that the value of the pressure along the y axis on all the scales is that which corresponds to $\log B_0 = \log b_0 = 2.98$, or $B_0 = b_0 = 955$ mm. The various pressure scales are logarithmic, and the change of the size of the units is such that pressures appropriate to the various levels lie above each other.

It will be noted that all the values of these coordinates except y_1 are negative. This is because the diagram is located in the third quadrant, to the left of the y axis and below the x axis.

The diagram is presented schematically in figure 1. To the left of the origin on the x axis is the temperature scale. Parallel to the temperature scale, but at a certain distance c below it, is the sea-level pressure scale B. At intermediate points, computed from the equation for y_3 lie other parallel scales, showing pressures at various levels above sea level. The values measured on the temperature scale are called x_1, on the sea-level scale are x_2, and on the intermediate scale, x_3. (Two intermediate scales are shown here, x'_3 and x''_3, at distances of y'_3 and y''_3 below the x axis, corresponding to altitudes h' and h'' above sea level.) At either end of the horizontal scales are drawn vertical scales graduated to read altitudes above sea level. The property that points of equal pressure on the various scales may be joined by a straight line passing through the origin is illustrated by the two lines $B'b'_2 0$ and $b'_1 b'' 0$, in which $B' = b'_2$ and $b'_1 = b''$. The method of using the chart is shown by the straight line AB. If any two of the three elements (1) mean temperature of the air column, (2) station pressure, or (3) sea-level pressure, are known, it is possible by joining them with a straight line to read directly the third on the proper scale.

The equations for the preparation of the diagram as given by Schwerdt and Loebe, presented above, are convenient for deep layers in the atmosphere—from sea

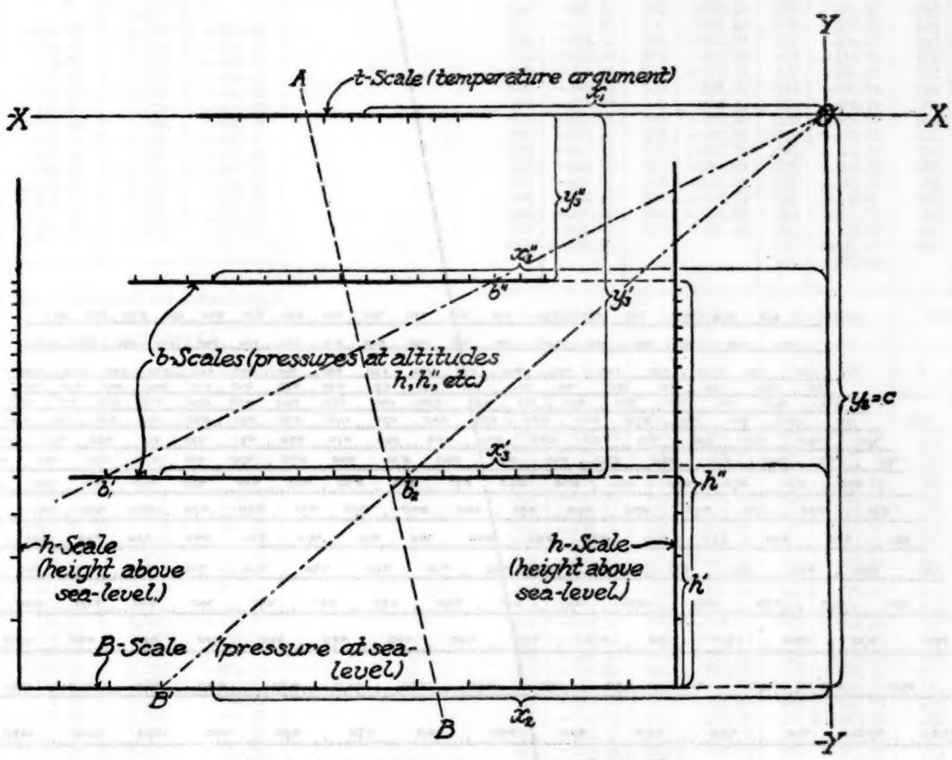

FIG. 1.—Schematic diagram of pressure reduction chart.

level to 10 kilometers or more. It is often desirable to have the diagram expanded vertically so that shorter air columns can be used with greater accuracy. This is only a matter of deciding upon the values of c and k, and of making appropriate transposition of the numerical factor between the denominator of x_1 and y_3, as discussed above. The following values have been found to be convenient for a diagram, which includes only the lower two kilometers of the atmosphere (see fig. 2):

$$x_1 = -533.333/(1+\alpha t) \qquad y_1 = 0$$
$$x_2 = 8{,}000\ (\log B - 3.07) \qquad y_2 = -400$$
$$x_3 = -20\ y_3\ (\log b - 3.07) \qquad y_3 = -400/(1+0.0008145h)$$

kinds of units. In figure 2 and in the coordinate just given, the units are millibars and the convenient value is 3,070. This figure shows the form of the finished chart with a line drawn upon it as an example. Owing to its small size and possible distortion in reproduction, this one is not suitable for practical use by the reader.

Tables 1 to 4 give the data for the plotting of a chart such as that here given. While these cover only this special form of chart, they are considered worthy of inclusion in view of the considerable amount of computation involved and the consequent saving of time to anyone who desires to construct such a diagram for his own use. The size of the chart depends, of course, upon the size of the units of length chosen; but to meet any demands for accuracy that are likely to arise, the tables have been given to two decimal places. Too much emphasis can not be placed upon the necessity for extraordinary care and precision in the location of the points. This diligence will yield a reward in the accuracy of the chart, which, for ordinary work, will be quite as satisfactory as the hypsometric formula and much simpler and quicker to use.

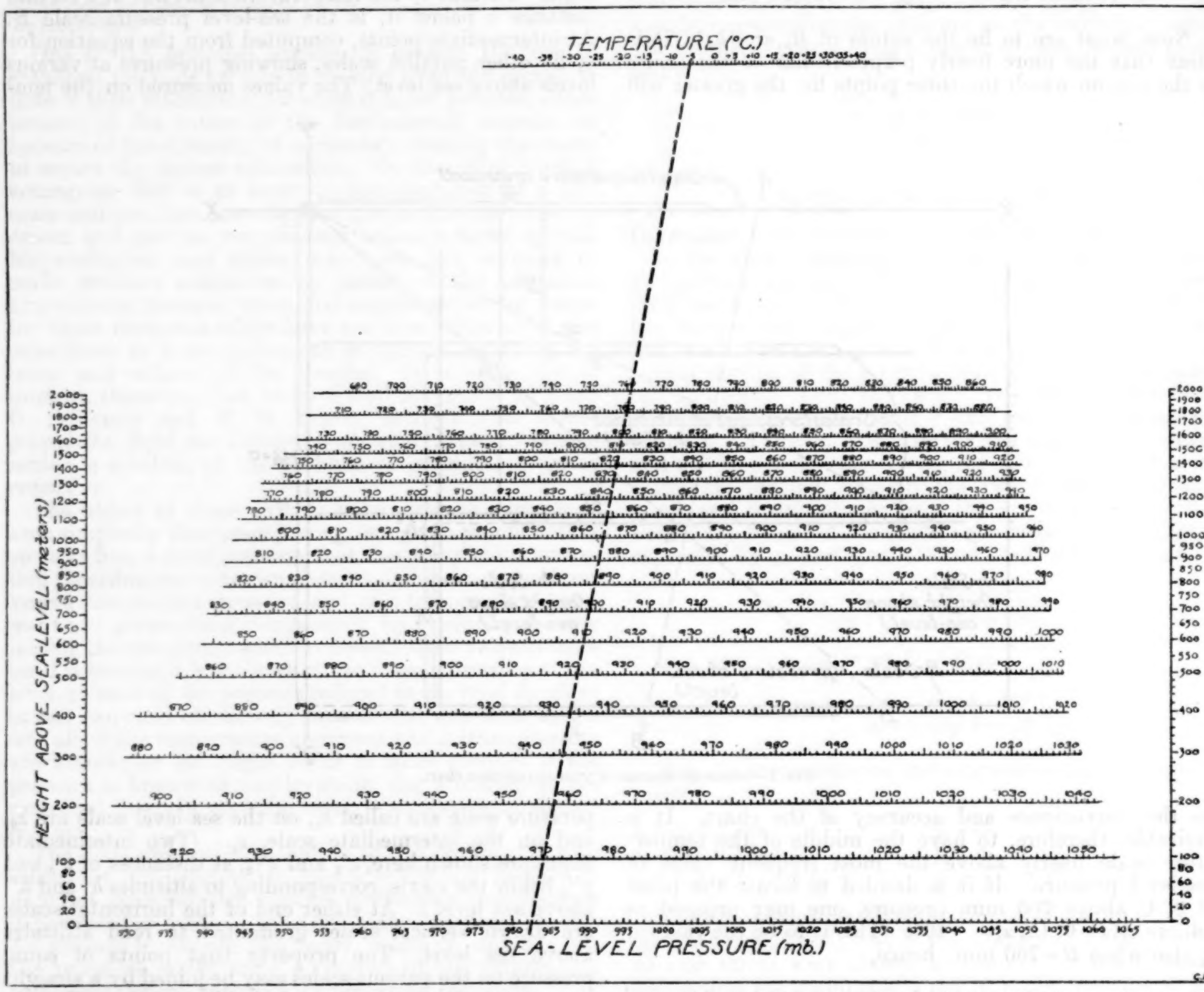

FIG. 2.—Pressure reduction chart. NOTE.—This chart is not to be used for actual pressure reductions, owing to its small size, the slight inaccuracies in the units divisions of the scales (every 5 mb. are accurately located), and possible distortion in reproduction.

A very important warning should be made regarding the numerical value of $\log b_0$ and $\log B_0$, for this is different with different pressure units for diagrams of the same size. For example, as was pointed out above, the authors use the value 2,980, and their pressure scales are in millimeters of mercury. If, on the other hand, the pressure units were millibars, this value would be 3,218. It will be readily seen that this is merely the result of the difference in the logarithm of equal pressures in the two

TABLE 1.—*Values of the t-scale* (x_1).

[$x_1 = -533.333/1+\alpha t.$]

t	x_1	t	x_1
°C.		°C.	
40	−465.06	0	−533.33
35	−472.62	−5	−543.30
30	−480.44	−10	−553.65
25	−488.51	−15	−564.40
20	−496.86	−20	−575.58
15	−505.50	−25	−587.21
10	−514.45	−30	−599.32
5	−523.72	−35	−611.94
0	−533.33	−40	−625.10

TABLE 2.—*Values of the B-scale* (x_2).

[$x_2 = 8(1000 \log B - 3070).$]

B	x_2	B	x_2
mb.		mb.	
930	−812.06	1,000	−560.00
935	−793.47	1,005	−542.64
940	−774.96	1,010	−525.36
945	−756.56	1,015	−508.16
950	−738.24	1,020	−491.08
955	−720.01	1,025	−474.08
960	−701.88	1,030	−457.18
965	−683.84	1,035	−440.38
970	−665.89	1,040	−423.66
975	−648.03	1,045	−407.02
980	−630.25	1,050	−390.46
985	−612.55	1,055	−373.98
990	−594.95	1,060	−357.57
995	−577.45	1,065	−341.25

TABLE 3.—*Values of the h-scale* (y_2).

[$y_2 = -400/1+0.0008145\,h.$]

h	y_2	h	y_2
m. above s. l.		m. above s. l.	
0	−400.00	650	−261.54
20	−393.59	700	−254.75
40	−387.38	750	−248.31
60	−381.36	800	−242.19
80	−375.53	850	−236.36
100	−369.87	900	−230.81
120	−364.38	950	−225.51
140	−359.06	1,000	−220.45
160	−353.88	1,050	−215.61
180	−348.85	1,100	−210.98
200	−343.97	1,150	−206.54
220	−339.22	1,200	−202.28
240	−334.59	1,250	−198.20
260	−330.10	1,300	−194.28
280	−325.72	1,350	−190.52
300	−321.45	1,400	−186.89
320	−317.30	1,450	−183.40
340	−313.25	1,500	−180.04
360	−309.30	1,550	−176.80
380	−305.46	1,600	−173.67
400	−301.70	1,650	−170.65
420	−298.04	1,700	−167.74
440	−294.47	1,750	−164.92
460	−290.98	1,800	−162.20
480	−287.57	1,850	−159.56
500	−284.24	1,900	−157.01
550	−276.25	1,950	−154.54
600	−268.69	2,000	−152.15

TABLE 4.—*Values of the b-scale* (x_3).

[$x_3 = y_2\,(1{,}000 \log b - 3{,}070)/-50.$]

h=2,000 m.		h=1,800 m.		h=1,600 m.		h=1,400 m.		h=1,200 m.	
b	x_3	b	x_3	b	x_3	b	x_3	b	x_3
Mb.		Mb.		Mb.		Mb.		Mb.	
690	−703.39	705	−719.56	730	−717.79	745	−739.54	780	−719.80
695	−693.85	710	−709.60	735	−707.50	750	−728.68	785	−708.58
700	−684.38	715	−699.71	740	−697.27	755	−717.89	790	−697.42
705	−674.97	720	−689.90	745	−687.11	760	−707.18	795	−686.34
710	−665.63	725	−680.14	750	−677.02	765	−696.54	800	−675.32
715	−656.36	730	−670.46	755	−667.00	770	−685.96	805	−664.37
720	−647.15	735	−660.84	760	−657.04	775	−675.45	810	−653.49
725	−638.00	740	−651.29	765	−647.16	780	−665.01	815	−642.68
730	−628.92	745	−641.81	770	−637.33	785	−654.64	820	−631.93
735	−619.90	750	−632.38	775	−627.56	790	−644.33	825	−621.25
740	−610.94	755	−623.02	780	−617.86	795	−634.09	830	−610.63
745	−602.04	760	−613.72	785	−608.23	800	−623.91	835	−599.67
750	−593.20	765	−604.48	790	−598.65	805	−613.79	840	−589.59
755	−584.42	770	−595.30	795	−589.14	810	−603.74	845	−579.16
760	−575.69	775	−586.18	800	−579.68	815	−593.75	850	−568.79
765	−567.03	780	−577.12	805	−570.28	820	−583.82	855	−558.49
770	−558.41	785	−568.12	810	−560.94	825	−573.96	860	−548.24
775	−549.86	790	−559.18	815	−551.66	830	−564.15	865	−538.05
780	−541.36	795	−550.29	820	−542.43	835	−554.02	870	−527.93
785	−532.92	800	−541.46	825	−533.26	840	−544.71	875	−517.86
790	−524.53	805	−532.68	830	−524.15	845	−535.07	880	−507.84
795	−516.19	810	−523.95	835	−514.74	850	−525.49	885	−497.89
800	−507.91	815	−515.28	840	−506.09	855	−515.97	890	−487.99
805	−499.67	820	−506.67	845	−497.14	860	−506.50	895	−478.14
810	−491.49	825	−498.10	850	−488.24	865	−497.09	900	−468.36
815	−483.36	830	−489.59	855	−479.39	870	−487.74	905	−458.62
820	−475.27	835	−480.80	860	−470.60	875	−478.43	910	−448.94
825	−467.24	840	−472.72	865	−461.85	880	−469.18	915	−439.31
830	−459.26	845	−464.36	870	−453.16	885	−459.99	920	−429.73
835	−451.01	850	−456.04	875	−444.52	890	−450.84	925	−420.21
840	−443.43	855	−447.78	880	−435.92	895	−441.75	930	−410.74
845	−435.58	860	−439.56	885	−427.38	900	−432.70		
850	−427.79	865	−431.40	890	−418.88	905	−423.71		
855	−420.04			895	−410.43	910	−414.77		
				900	−402.03				

h=1,000 m.		h=800 m.		h=600 m.		h=400 m.		h=200 m.	
b	x_3	b	x_3	b	x_3	b	x_3	b	x_3
Mb.		Mb.		Mb.		Mb.		Mb.	
795	−747.91	825	−743.78	850	−755.48	865	−802.42	900	−795.30
800	−735.91	830	−731.07	855	−741.80	870	−787.32	905	−779.74
805	−723.98	835	−717.94	860	−728.18	875	−772.30	910	−763.29
810	−712.12	840	−705.87	865	−714.66	880	−757.37	915	−746.92
815	−700.33	845	−693.39	870	−701.21	885	−742.53	920	−730.63
820	−688.62	850	−680.97	875	−687.83	890	−727.76	925	−714.44
825	−676.98	855	−668.64	880	−674.53	895	−713.08	930	−698.34
830	−665.42	860	−656.37	885	−661.31	900	−698.48	935	−682.31
835	−653.47	865	−644.17	890	−648.16	905	−683.96	940	−666.38
840	−642.48	870	−632.05	895	−635.08	910	−669.53	945	−650.53
845	−631.12	875	−619.99	900	−622.08	915	−655.17	950	−634.77
850	−619.82	880	−608.00	905	−609.15	920	−640.88	955	−619.09
855	−608.59	885	−596.09	910	−596.29	925	−626.70	960	−603.49
860	−597.42	890	−584.23	915	−583.50	930	−612.55	965	−587.97
865	−586.33	895	−572.45	920	−570.78	935	−598.50	970	−572.52
870	−575.29	900	−560.73	925	−558.13	940	−584.53	975	−557.16
875	−564.32	905	−549.07	930	−545.55	945	−570.62	980	−541.89
880	−553.40	910	−537.49	935	−533.04	950	−556.79	985	−526.68
885	−542.56	915	−525.96	940	−520.59	955	−543.04	990	−511.56
890	−531.77	920	−514.49	945	−508.21	960	−529.36	995	−496.51
895	−521.04	925	−503.09	950	−495.89	965	−515.74	1,000	−481.53
900	−510.38	930	−491.75	955	−483.64	970	−502.20	1,005	−466.63
905	−499.76	935	−480.47	960	−471.46	975	−488.72	1,010	−451.81
910	−489.22	940	−469.25	965	−459.33	980	−475.32	1,015	−437.05
915	−478.72	945	−458.09	970	−447.27	985	−461.99	1,020	−422.37
920	−468.29	950	−446.98	975	−435.27	990	−448.72	1,025	−407.76
925	−457.91	955	−435.94	980	−423.32	995	−435.52	1,030	−393.22
930	−447.59	960	−424.96	985	−411.46	1,000	−422.38	1,035	−378.76
935	−437.32	965	−414.03	990	−399.64	1,005	−409.31	1,040	−364.36
940	−427.11	970	−403.16	995	−387.88	1,010	−396.31		
945	−416.95	975	−392.34	1,000	−376.18	1,015	−383.36		
950	−406.84								

NOTE ON THUNDERSTORM BREEDING SPOTS.

By B. M. VARNEY.

[University of California, July 27, 1921.]

Mr. R. E. Horton's articles[1] on "Thunderstorm breeding spots" and "The beginning of a thunderstorm" recalls to mind my experiences some years ago in watching the growth and decay of local thunderstorms in Florida. I was fortunately located for thunderstorm observation. Less than 100 miles directly to the west lay the center of maximum thunderstorminess in the United States, the Tampa Bay region, where a 10-year average of 94 storms has been recorded. The central east coast of Florida, where the storm herein described took place, lies in a region of 70 to 80 storms annually, and hence may be considered a thoroughly successful thunderstorm factory.[2] So far as my observation goes (covering three thunderstorm seasons) the storms are so localized that their occurrence may be explained on the basis of rather small topographic details. There is here, in other words, a first-rate thunderstorm breeding spot.

The general summer conditions in peninsular Florida are, of course, extremely favorable to the development of local thunderstorms. Cyclonic weather control, while not entirely absent, is so obscured by local controls as to be little in evidence. Under such conditions the detailed features of the country as affecting local weather become correspondingly important. I believe that in the central east coast region, flat though it is, they constitute the major control. Along this coast extends a belt of flat, open-forest, sandy country, some 10 to 15 miles wide. This belt separates the two great sources of atmospheric moisture of the region. On the east is the Atlantic Ocean, and between it and the mainland, separated from the mild-temperatured waters of the Gulf Stream by a barrier beach, lies a wide, very shallow and very warm lagoon—the Indian River of citrus-fruit fame. On the west of the pine belt lies a vast area of what are locally known as "muck lands," which in their undrained portions and especially in the thunderstorm season expose broad areas of partly flooded marsh to an intense subtropical sunshine. The prevailing wind direction is then between south and east, essentially a summer monsoon, a partially reversed northeast trade wind. It is a significant fact that although large numbers of cumuli may usually be seen over the pine belt as a whole, the region of most frequent thunderstorm activity is the western part of it and the eastern part of the "muck lands." Doubtless the relatively dry, sandy soil of the pine land causes more active convection than the marsh country; while the onshore winds, besides bringing much moisture, cause the visible effects of convection to be most marked over the leeward side of the pine belt and the adjacent marsh. I have counted as many as six storms in operation simultaneously along this border zone, each apparently consisting of a single vigorously grown cumulo-nimbus in most cases, so narrow in proportion to its height that it shadows but a few hundred acres. Frequently, however, there is a merging into a massive cloud spreading over several square miles and displaying most impressive electrical energy. The spectacle of the towering heads, the black bases, and curtains of rain, all against a background of clear blue sky, is beautiful beyond description.

Being thus located in a thunderstorm-breeding spot, I had the good fortune on one occasion to be under a thunderstorm cloud during its formation, and to observe the growth and decay of the storm all within the short space of an hour. It was in midafternoon of a particularly hot and still day when a dark clot of cloud formed directly overhead. For some minutes nothing of it was visible except its gradually spreading shape, which grew rapidly darker and soon cast its cool shadow over many acres, while moving with an almost imperceptible motion inland. Presently occurred one of the most splendid cloud phenomena I have seen. The combined growth of the cloud and its westerly drift having maintained the eastern side of it approximately in the zenith, there suddenly emerged from behind the black base and far aloft a number of gray and partly sunlit protuberances, the turbulent heads of the upper part of the cloud. The sense of cloud height which that flash of perspective afforded, I have never experienced before nor since. Motion of the air at the earth's surface was barely noticeable and from the east. The only signs of air motion at the base of the cloud were the faintly visible writhings of dark rags of vapor drawing in toward the edge of it. But aloft, the rapid bulging of the heads showed how violent were the ascending currents within the cloud. It would have been impossible to measure the full height of this cloud, and so the speed of its growth, even had I had the means, so close overhead was it. However, the protuberances emerged from behind the base certainly not more than 15 minutes after the beginning of formation. Assuming a growth in that time of 15,000 feet (from my experience in watching other Florida storms this is a very moderate estimate), the velocity of updraft would be 16.6 m. p. s., or 37 + miles per hour.

Muttering of thunder soon became audible. Shortly thereafter a gray drapery of rain was lowered to earth perhaps 500 yards away, and in it the forms of the pines stood like ghosts, the more distant more ghostly than the nearer. By the time the first lightning flash occurred (not more than 20 minutes after I first observed the cloud overhead) the cloud had drifted toward the west sufficiently for a magnificent view up its side to be possible. I estimated the angular altitude of the highest visible part of it as never less than 45°, and during most of the time much more than that, so very slow was the horizontal motion. The rain lasted some 15 minutes, and within an hour from the first observation the cloud had nearly evaporated. This little storm was but one of several that developed along the margin of the pine belt during that afternoon, the others, however, being too distant to afford more than the usual wonderful cloud scenery of a Florida summer.

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[1] MO. WEATHER REV., April, 1921, 49: 93-94.

[2] Alexander, W. H.: Distribution of thunderstorms in the United States. MO. WEATHER REV., vol. 43, no. 7, July, 1915, pp. 322-340, chart no. 83.

Cf. also Henry, A. J.: Progressive movement of thunderstorms. MO. WEATHER REV., Sept., 1896, 24: 331-332.

THE DISTRIBUTION OF RAINFALL OVER RESTRICTED AREAS.

By ALFRED J. HENRY, Meteorologist.

[Weather Bureau, Washington, D. C., July 22, 1921.]

A correspondent has recently raised the question, What is the variation in intensity of rainfall in all directions from the center of a rainstorm?

The rains of eastern United States naturally fall into two great groups, first, cold-weather or cyclonic rains and, second, warm-weather rains, comprising for the most part convective and thunderstorm rains. It is quite probable that a further distinction should be made or not the rainfall at the geographical center of a rainstorm is greater than at some distance from the center. It is a matter of common observation that the rainfall increases from zero at the margin of the storm to what may be called the average intensity at some unknown distance therefrom. In the absence of observational material little progress can be made toward a satisfactory solution of the problem. What is needed is a close net-

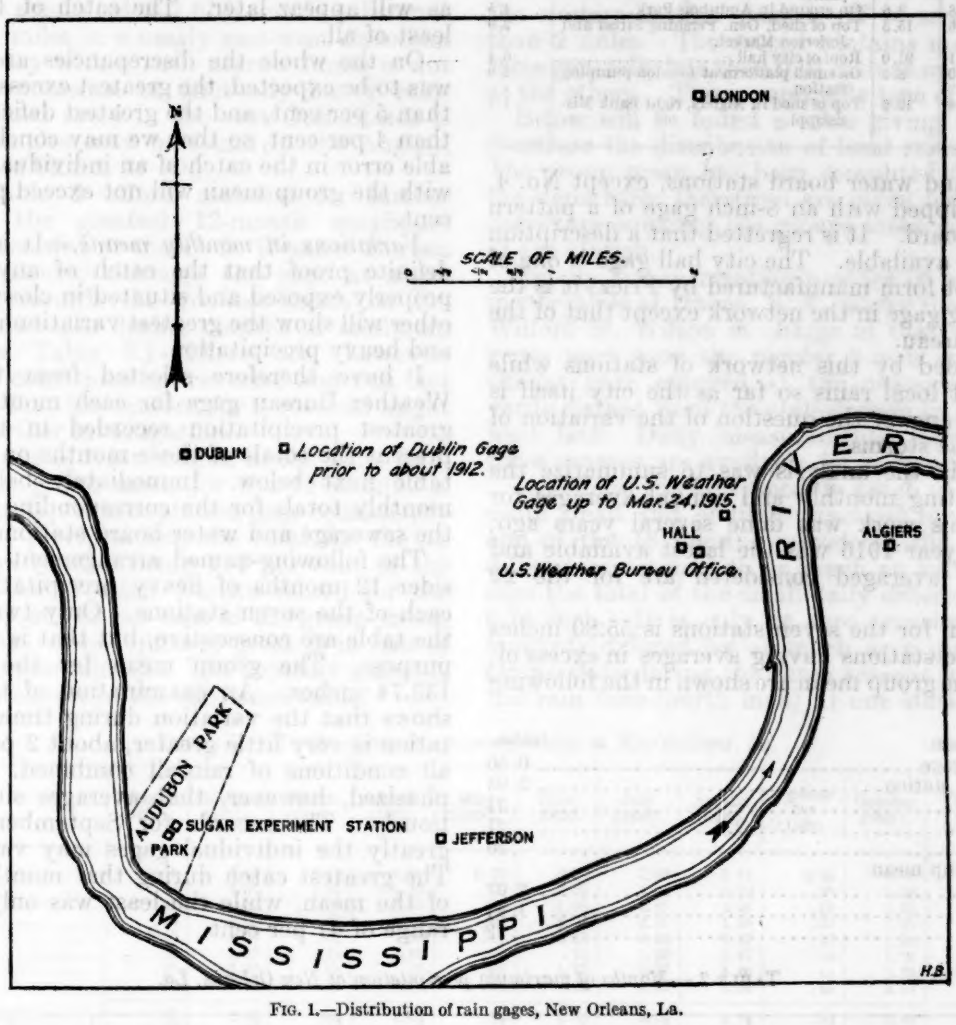

FIG. 1.—Distribution of rain gages, New Orleans, La.

to take account of the latitude effect or distance inland from a large body of water. Rains of the first group, as a rule, are rather widely distributed and of rather uniform intensity, but rains of the second group are, on the other hand, largely local in character and may vary greatly in intensity with distance from the geographical center of the storm.

The distribution of precipitation about the center of a barometric depression has been studied by a number of meteorologists, but the results of their studies refer, almost exclusively, to the geographic distribution about the center rather than to the intensity of the rainfall in different parts of the storm.

It is not known with any degree of certainty whether

work of gaging stations placed at uniform distances apart so as to cover completely some restricted area.

The city of New Orleans, La., through its sewerage and water board maintains a network of six rain-gaging stations within the city limits and to this number two additional gages may be added, viz, those maintained by the Weather Bureau and the sugar experiment station, although the latter gage is exposed within a few feet of one of the sewerage and water board gages. There is available, therefore, in reality but seven gages within an area of, say, roughly 50 to 60 square miles, or one gage to about 8 square miles. Details as to exposure of these gages will be found in the table next below and the position of the gages may be seen from figure 1.

TABLE 1.—*Rainfall stations in New Orleans, La. Nos. 1 to 6 are maintained by the Sewerage and Water Board of New Orleans.*

No. and name of station.	Elevation above ground, feet, in—		Location and exposure of gage.	Distance from U. S. Weather Bureau gage.
	1895	1918		*Miles.*
U. S. Weather Bureau.	78.0	71.0	Roof old customhouse	....
Sugar experiment station.	3.4	3.4	On ground in Audubon Park	4.5
1. Dublin	9.2	21.5	On retaining wall at water purification plant.	3.8
2. Park	3.8	3.6	On ground in Audubon Park	4.5
3. Jefferson	20.6	15.3	Top of shed, Gen. Pershing Street and Jefferson Market.	2.9
4. City hall	77.1	91.0	Roof of city hall	0.4
5. London	7.0	8.5	On small platform at London pumping station.	2.9
6. Algiers	19.8	19.6	Top of shed in Algiers, right bank Mississippi.	1.1

The sewerage and water board stations, except No. 4, city hall, are equipped with an 8-inch gage of a pattern designed by the board. It is regretted that a description of the gage is not available. The city hall gage is one of the tipping-bucket form manufactured by Friez; it is the only self-recording gage in the network except that of the U. S. Weather Bureau.

The data afforded by this network of stations while serving to delimit local rains so far as the city itself is concerned do not answer the question of the variation of the intensity of the storms.

Our first step in the analysis was to summarize the results by computing monthly and annual averages for each station. This work was done several years ago; at that time the year 1916 was the latest available and consequently the averaged considered are for the 22 years, 1895–1916.

The group mean for the seven stations is 55.80 inches for the year. The stations having averages in excess of, or below that of the group mean are shown in the following exhibit:

	Inches.
Stations above the mean:	
Weather Bureau gage	0.50
Sugar experiment station	3.03
Park gage	.31
Jefferson gage	.21
London gage	.20
Stations below the group mean:	
Dublin gage	2.07
Algiers gage	1.44
Hall gage	.72

From the above it appears that sewerage and water board stations, London, Jefferson, and Park, agree very closely with the group mean. The roof exposed gage of the Weather Bureau also agrees closely, being half an inch above the group mean. The Hall gage, the other characteristic roof exposure, gives an annual mean 0.72 inch below the group mean.

Sugar experiment station (New Orleans, No. 2), exposed side by side with sewerage and water board gage No. 2, catches the greatest amount of precipitation of any of the stations in the group the excess above the group mean being 3.03 inches. The excess above the mean of the monthly amounts is of course much greater, as will appear later. The catch of the Dublin gage is least of all.

On the whole the discrepancies are not greater than was to be expected, the greatest excess being a little more than 5 per cent, and the greatest deficit being a little less than 4 per cent, so that we may conclude that the probable error in the catch of an individual gage as compared with the group mean will not exceed plus or minus 5 per cent.

Variations in monthly means.—It is assumed without definite proof that the catch of any number of gages properly exposed and situated in close proximity to each other will show the greatest variation in times of frequent and heavy precipitation.

I have therefore selected from the record of the Weather Bureau gage for each month of the year, the greatest precipitation recorded in the 22 years, and present the totals of those months on the top line of the table next below. Immediately below are given the monthly totals for the corresponding months at each of the sewerage and water board stations.

The following-named arrangement enables us to consider 12 months of heavy precipitation as recorded at each of the seven stations. Only two of the months in the table are consecutive, but that is not material to our purpose. The group mean for the seven stations is 133.74 inches. An examination of the results in table shows that the variation during times of heavy precipitation is very little greater, about 2 per cent, than under all conditions of rainfall combined. It should be emphasized, however, that averages should be used cautiously. The records for September, 1898, show how greatly the individual gages may vary from the mean. The greatest catch during that month was 121 per cent of the mean, while the least was only 74 per cent, or a range of 47 per cent.

TABLE 2.—*Months of maximum precipitation at New Orleans, La.*

Stations.	January (1915).	February (1903).	March (1903).	April (1911).	May (1912).	June (1895).	July (1908).	August (1914).	September (1898).	October (1915).	November (1898).	December (1905).	Total.
U. S. Weather Bureau	8.42	10.20	14.61	13.76	16.80	9.74	11.03	8.47	13.90	12.07	5.17	14.43	138.60
Sugar experiment station	6.28	10.53	9.08	13.09	11.95	11.06	12.16	9.75	19.55	12.52	7.09	13.64	136.70
Dublin	6.88	10.44	14.73	11.54	10.99	12.14	11.06	11.23	15.88	11.15	6.70	13.50	136.24
Park	7.33	10.33	8.96	12.31	11.66	11.40	11.43	9.29	18.16	12.46	9.14	13.62	136.09
Jefferson	7.32	9.44	7.90	12.82	11.29	12.33	11.09	7.81	16.40	12.17	6.80	12.57	127.94
City hall	8.20	9.21	12.59	13.57	16.91	8.35	10.91	8.70	16.73	12.40	6.03	12.73	136.33
London	7.16	10.02	13.68	11.41	12.61	7.68	9.74	7.30	16.97	10.37	6.56	12.68	126.18
Algiers	7.62	9.45	12.76	12.36	14.43	8.04	11.36	10.90	11.94	14.30	4.71	13.97	131.84
Average	7.40	9.95	11.79	12.61	13.33	10.09	11.10	9.18	16.19	12.18	6.52	13.39	133.74
Range (inches)	2.26	1.32	6.83	2.35	5.92	4.65	2.42	3.93	7.61	3.93	4.43	1.86	....
Per cent of average	30	13	58	19	44	46	22	43	47	32	68	14	....

It may be interesting to inquire into the circumstances attending the precipitation of the month in question. September, 1898, was a month of phenomenally heavy rain in the entire State of Louisiana due to the fact that three separate barometric depressions from the Gulf of Mexico advanced over the State. These depressions gave at New Orleans three periods of rainfall of two, three, and five consecutive days, respectively, the total precipitation at New Orleans being 1.67, 3.58, and 7.94 inches for each of the periods. Since there is no surface relief in southeastern Louisiana the vertical convection which produced the rains must have been inherent in the cyclonic circulation of the individual storms. The variation at New Orleans amounted to 7.61 inches in a distance of not more than 4 miles in a nearly east-west direction.

Why it should vary within such narrow limits is not apparent. The phenomenon of unusually heavy rainfall over circumscribed areas in the east Gulf States is not new; good examples may be found in the August, 1916, REVIEW. (See Charts 94–99.)

The data of Table 2 afford material for further study. Curiously, the greatest 12-month maximum precipitation was recorded at the U. S. Weather Bureau station—a roof exposure, although the gage at sugar experiment station records the greatest catch on the mean of the year and also during months of minimum precipitation. (See Table 3.) There are, however, months when these conditions are reversed and this fact leads us to suspect that the reasons for a reversal might be discovered by further investigation.

Treating the months of least rainfall in the same way, it is found that the group mean for the 12 months is 15.82 inches. Sugar experiment station gage consistently records the greatest precipitation, the total for the 12 months of minimum rainfall being 124 per cent of the group—meanwhile the Weather Bureau record for the same 12 months was but 83 per cent of the group mean, a range of 41 per cent, or not quite so great as in case of the months of maximum rainfall. The monthly amounts for each station are shown in the subjoined table:

TABLE 3.—*Months of minimum precipitation at New Orleans, La.*

Stations.	January (1902).	February (1911).	March (1916).	April (1910).	May (1898).	June (1907).	July (1896).	August (1899).	September (1899).	October (1898).	November (1903).	December (1913).	Total.
U. S. Weather Bureau	0.97	1.35	0.64	0.90	0.02	0.98	2.92	2.31	0.35	0.78	0.18	1.78	13.18
Sugar experimental station	1.44	1.46	1.91	1.15	.05	2.83	4.44	1.74	.30	1.90	.23	2.14	19.59
Dublin	.41	.97	.58	1.28	.00	1.08	3.17	3.26	.29	1.65	.29	1.36	14.34
Park	.76	1.33	.78	1.08	.02	2.70	4.35	1.94	.32	1.93	.24	1.92	17.37
Jefferson	1.06	1.07	.91	.98	.17	1.62	4.20	3.32	.49	1.98	.15	1.82	17.77
City hall	.85	1.17	.73	.88	.00	.75	3.29	2.42	.36	1.21	.12	1.87	13.65
London	.68	1.48	.68	.88	.65	1.73	3.25	4.46	.44	1.09	.17	1.40	16.91
Algiers	.71	1.72	.36	1.07	.28	.62	3.13	2.64	.44	1.17	.28	1.34	13.76
Average	.86	1.32	.82	1.03	.15	1.54	3.59	2.76	.37	1.46	.21	1.70	15.82
Range	1.03	.75	1.55	.40	.65	2.21	1.52	2.72	.20	1.20	.17	.80	....

Before concluding this study I have made a short examination of the variations in the 24-hour catch at the various gaging stations, using for this purpose the records of 1919 only. It would be desirable to extend the examination to other years but time was not available.

Twenty-eight dates in that year were selected on each of which the rainfall at one or more stations in the group amounted to an inch or more. A group mean was computed, and departures were tabulated for each date. The results appear in the table next below. In the great majority of cases the variations are small and unimportant. On 15 of the 28 dates the differences at one or more measuring points equaled or exceeded half an inch and on 5 out of the 28 dates differences of as much as an inch or more were recorded. Some examples of irregular distribution follow:

On August 13, 2.38 inches of rain fell at the London station, 0.61 at the United States WEATHER BUREAU, 1.52 at Algiers, and 0.54 at city hall. These stations are in a north-south line, approximately within an area 2 miles wide by 3 miles long. No rain fell at the other stations within the city limits.

On August 5 the rainfall was confined to the two stations, Jefferson and Park, 0.47 falling at the former and 1.56 at the latter. Both stations are in the same part of the city in a nearly east-west line and distance from each other not quite 2 miles. The heaviest rain was at the western station shading off to zero in a little more than 2 miles. The record contains many cases of light rains generally less than 0.04 inch at one station and none at the others. This is especially true of the warm season.

Below will be found a table giving the dates used to illustrate the distribution of local rains at New Orleans. The group mean has been computed for each date and the departures therefrom are given for each station. A departure equaling the groups mean signifies no rainfall at the station.

Finally I may mention a series of rain-gage measurements made at Ithaca, N. Y., under the direction of Prof. Wilford M. Wilson in charge of that station. The two gages used were the regular 8-inch station gage and a similar gage exposed at the evaporation station, 374 yards distant from the station gage in a practically east-west line. Daily measurements May to October for three seasons are available for comparison.

In general the differences in catch of the two gages are quite small and of little practical importance. In but one of the 18 months considered did the accumulated differences amount to as much as half an inch; in this case the total of the small daily differences amounted to 0.74 inch. It is only on rare occasions that the daily amounts differed by as much as a quarter of an inch. On no date during the three seasons was there substantial rain (one-fourth inch) at one station without a like rain at the other. In this respect the record differs from that at New Orleans.

TABLE 4.—*Distribution of local rains at New Orleans, La., 1919, and departure from the group mean in each case.*

[Inches and hundredths.]

	January.		February.		March.	April.			
Dates	16	22	20	25	26	3	6	10	15
Group mean	1.02	1.67	1.38	1.37	1.29	1.60	2.42	1.10	1.34
Dublin	− .09	− .27	− .19	.00	+ .18	− .28	− .08	− .44	+ .01
Park	+ .01	+ .13	+ .03	+ .10	+ .41	+ .03	+ .22	+ .06	+ .10
Jefferson	+ .05	+ .04	+ .24	+ .31	− .04	+ .07	− .20	+ .24	− .05
Hall	+ .05	+ .08	+ .08	+ .12	− .13	+ .09	.00	+ .17	+ .03
Algiers	+ .27	+ .05	+ .30	− .18	− .32	+ .05	+ .04	+ .25	− .15
London	− .31	− .03	− .47	− .37	− .13	− .02	.00	− .27	+ .04
Weather Bureau	+ .18	+ .18	.00	+ .19	− .12	+ .17	− .04	+ .12	+ .19

TABLE 4.—*Distribution of local rains at New Orleans, La., 1919, and departure from the group mean in each case*—Continued.

	May.			June.			July.		
Dates	12	26	29	2	13	24	12	20	25
Group mean	1.60	1.62	0.66	0.53	1.72	0.98	1.61	0.62	1.93
Dublin	+ .63	− .51	+ .27	+1.22	− .51	− .11	+ .17	+ .34	− .13
Park	+ .10	+ .20	+ .44	− .46	− .01	− .14	+ .79	+ .39	+ .62
Jefferson	− .46	− .02	+ .52	− .45	+ .16	− .31	+ .46	+ .09	− .55
Hall	− .33	+ .01	− .36	− .36	− .11	+ .21	+ .08	+ .06	− .08
Algiers	+ .19	+ .16	− .29	− .53	− .15	+ .01	− .34	− .33	+ .82
London	− .13	+ .18	− .55	+ .55	− .35	− .16	−1.05	− .54	− .67
Weather Bureau	+ .28	− .23	− .32	− .34	− .39	− .23	− .06	+ .02	− .20

TABLE 4.—*Distribution of local rains at New Orleans, La., 1919, and departure from the group mean in each case*—Continued.

	August.			September.		October.			November.	
Dates	5	13	24	7	13	4	5	16	9	10
Group mean	0.34	0.74	0.99	0.93	1.47	1.10	1.00	0.65	0.94	3.51
Dublin	− .34	− .74	.00	+ .24	− .37	− .03	− .24	+ .44	+ .52	+ .69
Park	+1.22	− .74	− .46	− .24	+ .44	.00	− .66	+ .40	− .40	− .07
Jefferson	+ .13	− .74	− .09	+ .38	+ .36	− .31	+1.32	− .16	+ .01	− .38
Hall	− .34	− .20	+ .66	+ .02	− .19	+ .02	− .19	− .65	− .52	+ .80
Algiers	− .34	+ .78	+ .36	− .12	− .05	+ .29	− .13	− .65	+ .41	− .47
London	− .34	+1.64	− .47	− .29	− .17	+ .01	+ .30	+ .60	− .03	− .57
Weather Bureau	− .34	− .13	+ .66	− .11	− .29	− .10	− .36	− .65	+ .38	− .63

SUBSTANCES DISSOLVED IN RAIN AND SNOW.

By SHERMAN SHAFFER.

[Mount Vernon, Iowa, June 10, 1921.]

The determination of the character and quantities of the substances dissolved in rain and snow is of considerable interest and importance. My work is a continuation of the rain and snow analyses which have been made at Cornell College for a number of years.

The samples for analysis were collected in enameled-ware pans, at an open spot near the center of the village of Mount Vernon, Iowa. Mount Vernon is a town of about 2,100 population, situated 17 miles from a manufacturing center, and with no industries of its own. The samples were analyzed as soon as possible after they were collected. They were analyzed under ordinary laboratory conditions, but every precaution was taken to avoid contamination.

Forty-five samples of rain and snow were analyzed, during the period from August 18, 1920, to June 1, 1921. The precipitation during this period was 20.97 inches, 18.14 inches of rain and 34 inches of snow. Twelve inches of snow are taken as equal to one inch of rain.

The nitrates which fell during this period amounted to 0.60126 pounds per acre, assuming that 1 inch of water on 1 acre weighs 226,875 [1] pounds. The average [2] content was 0.3 part per million. The highest nitrogen content was 1 part per million on January 4, 1921. The amount of nitrates is influenced by the length of the interval between rains. A curve drawn for intervals between rains as abscissæ and nitrates per inch of rain as ordinates tends to rise as the interval is increased. There is no noticeable variation of the amount of nitrates with the seasons. On the contrary, the average through the year is quite constant. When the amount of nitrate per inch of rain for each month is compared with the rainfall in inches for each month, it is found that the nitrates are greater when the rainfall is less—that is, the solution is more concentrated, as might be expected. When the nitrates are determined by the phenolsulphonic method and no sodium carbonate is added before evaporating the water, no nitrates are found. This would seem to indicate that all the nitrate is in the form of free nitric acid. If this is true, the ammonia present must be united with some other acid radicle, or it would combine with the nitric acid.

The nitrites totaled 0.03985 pound per acre. The highest figure was 0.03 part per million on May 17, 1921. The average was 0.0033 part per million. A curve drawn for intervals between rains as abscissæ and nitrites per inch of rain as ordinates showed an increase with an increasing interval, but the curve was very irregular. The nitrites, like the nitrates, tended to greater concentration when there was less rain, but this tendency was not so marked as in the case of the nitrates.

The total amount of free ammonia was 1.48045 pounds. The highest ammonia was in the snow of November 27, 1920, which tested 2.1 parts per million. The average was 0.47 part per million. On the whole, no difference was found in the amounts of substances dissolved by snow and by rain under the same circumstances. This differs from the results of former investigators, who found that snow did not dissolve as much of the substances as did rain.

The albuminoid ammonia amounted, during the period, to 1.16022 pounds per acre. The highest being 2 parts per million, on December 13, 1920, and the lowest 0 on April 1, 1921. The average was 0.38 part per million, considerably less than the free ammonia. A curve drawn between albuminoid ammonia per inch of rain and number of days between rains showed a very striking increase of ammonia with increase of interval. The albuminoid ammonia remained on the average fairly constant throughout the year, as did the free ammonia. Both were lower in the spring than during the fall and winter.

A total of 34.43179 pounds of chlorides per acre was found. The average chlorine content was 10.1 parts per million. The highest was 49.7 parts per million. The chlorides were higher during the winter and spring than during the fall. They were not found to be present in constant proportion as was reported by former investigators, but varied from 3.5 parts per million to 49.7. The chlorides show the same tendency as the other substances to be more concentrated when the rainfall is less. A curve between chlorides and intervals of time shows a tendency toward increase in chlorides with increase in time interval.

The total sulphates amounted to 327.0619 pounds per acre, figured as SO_3. The average was 29.9 parts per million, and the highest 101.2, on May 17, 1921. The sulphates undoubtedly come from the combustion of the sulphur in coal used for heating. The amounts found rise from none in August, to 4.8 pounds per acre in September, and to 66.2 pounds per acre in February, after which they again decline.

Thirteen determinations of sulphurous acid were made, using N/10 iodine-potassium iodide solution against N/10 sodium thiosulphate solution. Seven of the tests

[1] The latest edition of *Smithsonian Meteorological Tables* gives the weight of an inch of rainfall per acre at a temperature of 62° as 113 short tons or 226,000 pounds.—Ed.
[2] The arithmetical mean of all of the analyses.

showed none present. The average of the other tests was 1.43 parts per million. The highest was 1.8 parts per million on May 17, 1921.

The total nitrogen which fell, in all forms, was 3.28178 pounds per acre. This was divided as follows: As nitric acid, 5.74 per cent; as nitrous acid, 0.511 per cent; as ammonia, 93.73 per cent.

Grateful acknowledgment is made of the kind assistance and suggestions of Dr. N. Knight in carrying out this work.[3]

TABLE 1.—*Chemical contents of rain and snow at Mount Vernon, Iowa (pounds per acre).*

[× means "not tested."]

Date.	Precipitation.	Nitrates.	Nitrites.	Free ammonia.	Albuminoid ammonia.	SO_3	SO_2	Cl
1920.	*Inches.*							
Aug. 13	0.35	×	×	0.00357	0.02857	None.	×	×
Aug. 20	.32	0.02177	0.00021	.11975	.00726	None.	×	0.51529
Sept. 23	.20	.01724	.00018	.02540	.01829	None.	×	.16103
Sept. 26	.12	.02177	.00060	.01851	.01306	1.7962	×	.19321
Oct. 15	.06	.00544	.00007	×	×	1.0478	×	.07239
Oct. 15	.30	.03742	.00020	.05443	.04218	3.6742	×	.23814
Oct. 19	.05	.00454	×	×	×	×	×	×
Oct. 20	.30	.00513	.00007	.04627	.01905	×	×	.23814
Nov. 1	.65	.02211	.00044	.17690	.01622	×	×	×
Nov. 1	.05	.00170	.00003	×	×	×	×	×
Nov. 8	.95	.06464	.00150	.06033	.04309	17.4520	×	1.52980
Nov. 14	.16	.01451	×	×	×	2.6490	×	×
Nov. 22	.06	.00136	None.	×	×	.93895	×	.11975
Nov. 27	.32	.00726	.00015	.15241	.05806	3.9917	×	.63867
Nov. 30	.05	.00227	.00005	×	×	2.0979	×	.14062
Dec. 3	.60	.01361	.00007	.05931	.05443	6.5318	×	×
Dec. 13	.55	.04990	.01247	.00499	.24948	13.0977	×	1.32220
Dec. 22	.32	.02903	.00004	.01452	.05225	10.8864	×	.51503
Dec. 25	.50	.03402	.01134	.02717	.04082	10.4328	×	1.20200
1921.								
Jan. 4	.05	.01134	.00001	×	×	1.5309	×	.56360
Jan. 13	.32	.00726	.00004	.00290	.1814	×	×	.63867
Jan. 25	.16	.01996	×	.0508	.01452	×	0.2141	.57698
Feb. 8	.10	.01588	.00014	.01814	.01593	×	.0079	.36061
Feb. 22	.20	.01814	None.	.07258	.02177	6.62256	×	.72122
Mar. 5	.10	×	×	.03175	×	3.2886	×	.32206
Mar. 7	.12	.01225	.00019	.02286	.00435	2.2045	×	.19323
Mar. 14	3.00	Trace.	.00068	Trace.	.13608	61.2360	.0340	7.21224
Mar. 24	.06	.00476	.00014	×	×	1.1975	×	.14424
Mar. 29	.05	.00397	.00010	×	×	.0907	×	.08051
Apr. 6	.20	Trace.	.00014	.01814	.00717	2.4494	×	.64411
Apr. 6	.50	None.	.00034	.00907	None.	11.2266	×	.39690
Apr. 8	.65	Trace.	.00007	.00295	.04128	×	.0590	.51597
Apr. 14	.25	.01985	.00028	.03175	.02268	4.9494	None.	.40257
Apr. 15	1.75	.00992	.00119	.02381	.01588	37.7055	×	2.10357
Apr. 17	1.00	None.	.00227	.00227	Trace.	13.6080	×	1.61028
Apr. 21	.25	.01134	.00011	.02381	.00340	×	×	1.20771
Apr. 23	.05	.00284	×	×	×	×	×	×
Apr. 26	.60	.00680	.00027	.03810	.04899	.2722	None.	.72122
Apr. 27	.75	.01701	Trace.	.01021	.00677	23.1336	None.	1.60306
May 1	.45	.00510	.00020	.03614	None.	8.7322	None.	.72463
May 10	1.10	×	None.	.02994	.00998	10.2287	None.	1.77131
May 7	.05	.00397	.00125	×	×	.39690	×	.12020
May 11	.55	.00624	.00062	.04491	.00499	10.1040	None.	×
May 17	.40	.03629	.00272	×	×	26.7624	.1633	2.34057
May 27	.45	.03572	.00122	.12247	.11022	9.6957	.0123	1.08184
May 31	.40	Trace.	.00045	.02903	.02177	6.8040	None.	.31752
June 1	1.50	×	×	.09526	.01361	10.2260	×	1.19070
Total	20.97	.60126	.03985	1.48045	1.16022	327.0619	.4906	34.43179

Twelve inches of snow have been taken to equal 1 inch of rain.

NITROGEN IN THE RAINWATER AT ITHACA, N. Y.[1]

By B. D. WILSON.

[Abstract reprinted from *Exp. Station Record*, U. S. Department of Agriculture, vol. 44, No. 9.]

Studies conducted at Cornell University on the amounts of ammoniacal and nitrate nitrogen added to the soil by rain showed that with an average annual rainfall of 29.31 inches, between May 1, 1915, and May 1, 1920, the soil received annually 12.51 pounds of nitrogen to the acre. Of this amount 11.5 pounds was in the form of ammoniacal nitrogen and 1.01 pounds in the form of nitrate nitrogen. The ammoniacal nitrogen fluctuated from month to month and from year to year, while the nitrate nitrogen remained more constant. The amount of total nitrogen in the rainwater was to a large extent dependent upon the amount of rainfall, a high nitrogen content accompanying a correspondingly high precipitation.

The rainfall during the spring and summer months contained more nitrogen than that falling during the other two seasons. The ammoniacal nitrogen decreased rather suddenly during August and continued low during September and October in spite of heavy rainfalls. This decrease is considered to be probably due to the atmosphere being washed comparatively free of ammonia by previous rains. Electrical discharges did not increase the nitrate nitrogen content of the rainwater to any considerable extent.

The amount of ammoniacal nitrogen brought down in the rain falling at Ithaca, N. Y., is said to be somewhat larger than that reported from many parts of the world, while the nitrate nitrogen content is about the same.

A bibliography of 12 references to the literature of the subject is given.

LONDON SMOKE FOGS.

By J. S. OWENS.

[Abstracted from *The Meteorological Magazine*, London, Mar., 1921, pp. 29-33.]

The Advisory Committee on Atmospheric Pollution has always recognized the fact that the measurement of atmospheric pollution by means of open-topped gages[1]—similar to rain gages—gives an incomplete statement of the case because only those particles of dust heavy enough to be precipitated find their way into the gage. Recently, however, a method of measuring the *suspended impurities* over cities has been established. Instruments were installed at the Meteorological Office, South Kensington, at Kew Observatory, and at 47 Victoria Street, Westminster. Continuous records are now available since October, 1920. From these records curves have been drawn showing the amount of suspended matter for each hour over a number of days. This has been done for ordinary week-days (exclusive of Saturdays and Sundays), and for Saturdays and Sundays separately. In drawing the curves the author splits up each group into foggy and non-foggy days.

When more data are available it is hoped a study of the graphs will make it possible to state definitely what proportion of the suspended impurity is due to domestic fires for heating and cooking and what to factory furnaces.

A survey of the curves already drawn shows the atmosphere least polluted between midnight and early morning when all classes of fires are practically dormant. On week days and Saturdays at about 6 a. m., (Sundays at 7 a. m.), a rapid increase in the amount and impurity starts, reaching a maximum about five hours later. About 10 p. m. a rapid fall starts, continuing until midnight when the minimum period sets in.

Referring to the curve for nonfoggy Saturdays, there is no sudden falling off in the amount of smoke after 1 o'clock when most factories close; on the contrary, there is a distinct rise and a very marked peak at 5 o'clock. The inference is clear that since the shutting down of factories does not bring about a marked reduction in the amount of impurity recorded, factory fires are not mainly responsible for the pollution. Thus both the quantity of suspended matter and its distribution point toward the domestic heating and cooking fires as being chiefly responsible.

From the somewhat brief data so far available, the writer ventures the opinion that the values plotted would indicate that domestic fires appear to be responsible for two-thirds of the total smoke in Westminster.—*H. L.*

[3] Cf. Trieschmann, J. E.: Nitrogen and other compounds in rain and snow. Abstract reprinted in MO. WEATHER REV., Nov., 1919, 47: 807.

[1] *Soil Science*, 11 (1921), No. 2, pp. 101-110.

[1] For an account of the amount of solid matter collected in gages, see the MO. WEATHER REV., March, 1921, 49; 159-160, "Atmospheric pollution."

REMARKABLE AURORA OF MAY 14-15, 1921.

By HERBERT LYMAN.

[Weather Bureau, Washington, August 1, 1921.]

In the United States, from latitude 40° northward, auroras of more or less brilliance are usually observed several times in the course of a year. The display of May 14–15, 1921, however, was exceptionally noteworthy in two particulars; first, its accompanying earth currents caused the greatest demoralization to telegraphic communication ever recorded, and secondly, it was seen in extreme southern latitudes with all the brilliance usually observed in the north. In geographic extent it was very widespread. Reports thus far received show that the display was witnessed from northern and central Europe westward over the Atlantic, across the United States and far over the Pacific, reaching as far south as Apia, Samoa.

THE AURORA AND COMMUNICATION.

The following reports taken from the press of the country will give a good idea of the great difficulties experienced by the telegraphic and cable companies as a result of the excessive earth currents accompanying the aurora. In contrast to this state of affairs it is interesting to learn that radio transmission was not only not hindered but in many cases the signals were reported to have come in even better than usual.

New York, May 15, 1921.—Telegraph service throughout the United States was impeded seriously last night by an electrical disturbance caused by the aurora borealis or northern lights.

The heaviest effect of the phenomenon was felt on the lines of the Western Union Telegraph Co. in the West and South, while those in New England, it was said, although under its influence, were not so badly affected.

Officials of the Western Union Telegraph Co. declared the cause of the disturbance to be due to an extra voltage, which entered the wires at one unknown point and left them at another. The variability of the extra voltage, which did not remain constant for more than a period of a few minutes, made it impossible to adjust the telegraphic apparatus and overcome the disturbance.

At the New York end of a wire which extends to Pittsburgh the current varied within a short time from 300° positive to 80°. The lights of the aurora borealis were reported visible in great brilliancy at Scranton, Pa., and points between there and Pittsburgh.

The greatest disturbance to the operation of the telegraph by the aurora borealis here was noted last night at 11.30 o'clock, when earth currents, due to the northern lights, registered 1,000 volts. The highest previous voltage recorded was 200, according to the wire chief of the Western Union Telegraph Co. The increasing voltage of earth currents was first noted Friday at 3 p. m.—*New York Times*, May 15, 1921.

Helena, Mont., May 15, 1921.—The electrical storm was said to be the worst in the history of the Mountain States Telephone & Telegraph Co.'s operations in Montana. Advices reaching here by relay from several repeating stations was to the effect that the storm extended in an arc from Chicago to San Francisco and into the Pacific ocean. The severity of the storm is indicated by the fact that for the first time in history the telegraph and cable lines to Alaska were completely out of commission for a time and that Territory isolated from the outside world.

COMPLETELY AT ITS MERCY.

Shortly before midnight it was learned that Denver, Salt Lake, San Francisco, Seattle, Spokane and Winnemucca, all important telegraph points were completely at the mercy of the elements. With frequency the electrical discharges would enter the earth from the heavens and completely polarize these points of entrance. Then for a few minutes the air and ground would be cleared and an attempt to resume operation would be made only to result in failure through the continued activities of the northern lights.

The condition of Helena was particularly severe. For only momentary remissions would the electrical discharge be drawn from the wires Polarization would be reported from Bozeman, with a report following immediately from Spokane that the center of activity had shifted to Spokane. Then Salt Lake would begin to report that the wire was cleared and the message would be suddenly cut short before other information could be transmitted.—*The Independent.*

Operators puzzled.—Those who saw the strange lights were not more puzzled than telegraph operators between Chicago and San Francisco whose machines cut up queer capers. For a time the instruments clicked away, sometimes sending what made sense and at other times sending dashes of almost intelligence which left operators wondering what was happening.—*San Francisco Examiner*, May 15, 1921.

French wires affected.—The disturbance which interrupted telegraphic transmission in the United States last week has been making itself felt also in France.

On Saturday night especially the operators at the central transmission stations came to the conclusion that a strange force had got into their instruments, for nothing would go right. Morse instruments, instead of making dots and dashes, recorded one long line. Hughes instruments produced words in what might have been an unknown language, and Baudot, of which French telegraphers are proud because it is very intricate, seemed possessed by evil spirits.

The phenomenon was first noticed in western France late on Friday evening and gradually spread eastward. All lines were not affected similarly, neighboring ones behaving normally or eccentrically from no known reason.

One feature was that while earth currents were disturbed, the wireless apparatuses remained unaffected.—*New York Times*, May 18, 1921.

The Western Union Telegraph Co. reports that the magnetic disturbances accompanying the aurora on May 15 blew out fuses, injured electrical apparatus, and did other things which had never been caused by any ground and ocean currents known in the past. It appears as though the company will probably have to send out ships to drag up the cables to repair the damage produced by straying currents.—*Scientific American*, New York, May 28, 1921, page 423.

Brewster, N. Y., building burned as a result of static electricity associated with the auroral display of May 15.—Static electricity, due to the aurora borealis, which was of unusual brilliance late Saturday night, caused a fire which totally destroyed the Central New England Railroad station in Brewster, N. Y., affected the telegraph and telephone system of the entire railroad system, and disorganized the circuits of the Western Union and Postal Telegraph Co.'s and put nearly all of the toll line circuits of the Southern New England Telephone Co. out of commission.

The electrical phenomenon was widespread over the country, starting in the early evening in some parts of the country and continuing until dawn. In this section the display appeared to be at its height between 11 and 12 o'clock, and it was at that time the static electric caused the fire in Brewster.

Unlike other displays of the aurora borealis, the shafts of light completely encircled the city and some of the time was directly overhead. It shot about in varicolored waves, creating a beautiful and at the same time an awe-inspiring spectacle. The disturbance did not abate, according to press reports, until the coming of dawn.

The fire in the Brewster railroad station started at 10:15 o'clock. Operator Hatch was working at the key when a flash of flame came out of it. He closed the key and started to pull the plug when another flash of flame came. Looking up, Hatch saw that the switchboard was in flames.—*Danbury Evening News*, May 18, 1921.

REPORTS OF OBSERVATIONS.

The descriptions below have been culled out from a large number sent in to the Weather Bureau. An effort has been made to select a few representative of the several sections of the country. For convenience they have been arranged approximately in belts extending across the country from east to west for each 5° of latitude. Thus the first belt takes in the area between the fortieth and forty-fifth parallels, the second that between 35° and 40°, etc.

Middletown, Conn.—A very bright auroral display was observed here on the evening of May 14. The sky was overcast until 10 p. m. As the clouds dissolved the aurora was noted in spite of the bright moonlight.

The focus of display was near the zenith in the vicinity of the star Arcturus. From that point streamers radiated in all directions constantly changing both in position and in intensity. Across these streamers pale green pulsating clouds drifted, in general from north to south, but occasionally assuming a spiral form around the zenith. They attained their maximum brightness near the zenith where they were especially conspicuous on account of their almost instantaneous changes in intensity.

Bright colors were noticed during the evening, but after the moon set about midnight, pale reds and blues appeared on the edges of the streamers and clouds. The display continued at intervals throughout the night. It was not more conspicuous in the north than in other directions.[1]—*Frederick Slocum.*

Syracuse, N. Y., June 18, 1921.—On the 14th of May I was in the university observatory showing students Jupiter and Saturn when I observed a display which looked like a beautiful pointed dome in the vicinity of Saturn or higher and farther east. * * * But the next day, the 15th, I made observations by measurements by the method I use. Two spots coalescing 41,000 miles across the longest way and a single spot 29,000 miles in diameter and 94,000 the longest way from outside to outside of the two groups which had both passed the center at a point 40″ to 60″ north of the center of the sun's disk. * * * seemed to explain the display.—*Prof. E. D. Roe, jr.*, Syracuse University.

Ashland, Ohio.—There was the single and double bow, the pale blue and the white light, and the first extra, which came at 2:30 a. m. At that hour the northeast sky suddenly became red, as if it were the reflection of a great conflagration on the earth. This great red cloud moved south and then straight west, along the zenith, until it reached the far western horizon. It remained several minutes, a beautiful red, and then turned to a brilliant white light, of surpassing beauty. A few patches of clouds made their appearance in the sky at this time, which added greatly to the sublimity of the scene.—*S. W. Brandt*, Cooperative Observer.

Ames, Iowa.—Against a clear moonlit sky a brilliant auroral display was observed between 8:30 and 10:30 p. m., May 14. The arch which was visible throughout this time except at short intervals, formed in our magnetic north and extended about 15° above the horizon they converged to a focus at a point somewhat variable in position but approximately 15° south and west of the zenith, which point, the magnetic zenith, became a center of radiation for the streamers. About 15 minutes before the maximum development of the display, streamers of red were seen to rise from the horizon a few degrees south of east and to extend through the radiant center to the horizon about the same distance north of west, forming an arch along a magnetic parallel.

The maximum degree of brilliancy was attained at 9:27 p. m. [90th meridian time] when the streamers from a large coronal area formed about the magnetic zenith, extending to the horizon in all directions, lighting the entire heavens. The radial streamers were visible within a few degrees of the moon which had just passed the first quarter. At this time a dark area a few degrees south on the horizon closely resembled an auroral arch, but a definite segment of a circle like that on the northern horizon could not be discerned.

The shades, tints, and hues, changeable and increasing from the beginning of the observation, now became more distinct and all of the primary colors appeared in varying degrees of intensity. Reappearing intermittently, the colors gradually faded away during the remaining hour of the display.[2]—*John E. Smith*, Iowa State College.

Des Moines, Iowa.—The first indications of the so-called "celestial conflagration," during the night of May 14–15, were observed about 9 p. m. Pale white, wavering beams of light covered nearly the entire visible sky. After a minute survey of the heavens was made, it was noticed that the "auroral arc" was missing, but at a point approximately 10° south of the zenith, a vast system of pulsating, shifting, and playing shafts of light converged in a quivering mass. At 9:25 p. m. the canopy of light assumed curtainlike tendencies with glittering columns of flame stalking across the northern horizon. Across the southern, streamers of white light seemed to filter down, resembling the bursting of a giant star shell. At 9:30 p. m. an observation was made for the northern arc, and it was noticed that in the north, reaching up probably 15°, there was a bank resembling an intensely purple cloud through which no stars could be seen. This formation was thought at first to be a cloud, but its appearance was of the nature of an auroral arc, minus the light. At 9:35 p. m. this peculiar cloud suddenly dissolved and took the usual form of the auroral arc, through which the stars could be seen shining brightly. Immediately the violent pulsations began radiating from the arc in the north. The sheets and streamers of light constantly played and pulsed, like puffs of breath against a window pane, low down, then rising up and up and into the ever-changing colored mass of quivering light, slightly to the south of the zenith.—*Arthur J. Haidle*, Observer, Weather Bureau.

Drexel, Nebr.—The aurora of May 14 first became visible in the northern sky at 9 p. m. It gradually advanced in a series of great arcs, passing beyond the zenith and toward the southern horizon. This display was the greatest and brightest of the three and covered the sky more completely than any ever observed at this station. At 9:40 p. m. the entire sky, except a thin strip along the southern horizon, was covered with intermingling masses of light. The predominating color was yellow, but splashes of red, orange, and green tints appeared at intervals in different parts of the sky.

The magnetic activity was probably greatest between 9:30 p. m. and 10:30 p. m. as the effect on telephone and telegraph instruments was greatest at this time. The aurora, however, continued overhead with undiminished brightness until after midnight. At 11 p. m. the heavens appeared like the roof of an immense gold-lined cave with stalactites (curtains) of light extending toward the earth. Streamers of delicately tinted light shot up from every part of the horizon. One Omaha newspaper likened the aurora to "a great tent of light that completely covered the city." Although the moon was shining brightly, it passed unnoticed amid the greater brightness of the aurora.

The phenomenon continued with gradually diminishing intensity until about daylight of May 15th.—*H. L. Choate*, Observer, Weather Bureau.

Portland, Oreg.—The phenomenon last night was said to be the most aggravating, from a telegraphic standpoint, in years. Wires which normally carry a voltage of 150 were charged as high as 450, either negative or positive, thus giving a variation of approximately 900 volts difference in potential. Electric lights were burning in the Western Union office with voltage drawn from the earth through ground wires at Spokane and Nampa. The delicate volt-millimeter needle, which ordinarily stands at zero, was jumping about like a compass needle, now registering 400 volts positive (current flowing toward Portland), and a few second later indicating the same amount of negative current.

At Walla Walla the northern lights were said to be hanging over the city much like a large umbrella, and they were reported clearly visible in other inland towns. Denver reported unaccountable complications due to ground wires drawing voltage from the earth. The demonstration, varying in intensity, has been constant for the last 36 hours, although the lights themselves were almost indistinguishable here last night on account of the hazy atmosphere.—*Oregonian*, May 15, 1921.

Across the sky a trifle to the west of north flashed horizontal rays of blue and red, the latter predominating. Beginning like a last fading ray of a glorious sunset the phenomena slowly took on changing hues. From the tops of downtown buildings and vantage points on the heights the view was wonderful. It began about 8:40 and continued until after 10.

Beginning with intermittent glow in the northern sky, the sheet of reddish and white light rose, each flash being higher than the preceding. After a time it seemed the level had been reached. Streamers shot high in the heavens, moving across the sky from east to west like the beams of a huge searchlight.—*Journal*, May 15, 1921.

Beaver, Utah, May 14–15.—Local spectators report that the Aurora resembled, at times, a huge fountain of fire, spouting brilliantly colored flames in every direction. A curious feature was the fact that it seemed to be moving toward the south, as this latitude, about 37° is south of the zone of frequency for auroral displays.—*Beaver Press*, May 20, 1921.

Washington, D. C.—At 8:45 p. m. at Chevy Chase, Washington, D. C., there was visible through a small rift in the clouds in the northeast an appreciable glow of greenish light characteristic of an auroral display. Later heavy clouds (with a thunderstorm) prevented any view of the display.—*C. F. Brooks.*

At about 11 p. m. near the navy yard (SE.), Washington, D. C., a brilliant display of the aurora was visible. The rays of light spread in all directions from a radiant point near the zenith. I awakened several friends to view the spectacle, got the clerks in a neighboring drug store to come out to see it, and telephoned to Mr. Shaw in Chevy Chase, who reported a thunderstorm in progress in the sky and no aurora visible.—*L. M. Pace* [from conversation with C. F. Brooks on May 17, 1921.]

San Francisco, Calif.—The aurora borealis, lights of various colors in the sky, common in the north but seldom seen as far south as San Francisco, startled many last night with what looked like a "shimmy of colors" in the heavens.

As far south as the Mexican border electric discharges in the sky were plainly visible, the first time in history, according to old-time residents.

Santa Fe train dispatchers say the lights were also clearly seen on the Mojave desert, nearly all points reporting having witnessed them for the first time within the records of the various weather offices.—*San Francisco Examiner*, May 15, 1921.

Grand Junction, Colo.—It is believed that it was a most unusual display of the "northern lights" or aurora borealis, which developed strange green phosphorescencelike wreaths, clouds, and odd shapes in the southern sky while the whole northern sky was by turns lavender, purple, red, and light green. It was wonderfully beautiful, weird, and aweinspiring. * * *

Andrew J. Halligan, merchant police, reports that a slight display of red aurora was visible Friday night, but nothing like the display last night.

At midnight directly overhead there were many bright flashes which looked like the beam of a powerful searchlight playing across the heavens. It would wink and go out, then instantly reappear. * * *

At midnight the whole northern part of the sky was a brilliant pale green.—*Daily News*, May 15, 1921.

Rome, Ga., May 14–15, 1921.—At 8 p. m. pale light noted from NW. to NNE., 15° above horizon; general intensification of light in north at 8:35; * * * 9:54 p. m. suddenly became very bright in ESE; * * * 11:57 p. m. active period begins. Many rapidly changing streamers from NNE. (streamers coming from bright arch at 45°).

[1] Reprinted from *Science*, New York, June 3, 1921, pp. 515–516.
[2] Reprinted from *Science*, New York, June 3, 1921, page 516.

* * * 3 a. m. only bright light from NW. to NE. at 40°.—*Robt. W. Graves, jr.*, Tremont Meteorological Observatory.

Austin, Tex.—The aurora borealis or northern lights was visible from 9 to 10 o'clock in the eastern heavens, while an hour later a "tequila moon" was visible.

During the period of visibility of the aurora lights were seen to shoot up from the horizon on the northeast and make an arc across the eastern skies toward the southeast.

The sky was of a dull red, and the lights shot up sometimes as many as half a dozen at a time.—*Austin American*, May 15, 1921.

San Antonio, May 14.—The aurora borealis or northern lights was visible in San Antonio for more than an hour Saturday night between 9:30 and 10:30 in a brilliant display of white shafts of light, patches, and spots. As far as known this is the first time that this phenomenon of the sky has ever been visible this far south.

The usual heavy static conditions which accompany the aurora borealis rendered the giant radio station at Fort Sam Houston useless at times.

The shifting paths of light and sudden illumination of the sky resulting in hundreds of calls to police headquarters by citizens who, unaccustomed to the visit of the northern lights were at a loss to determine the unusual conditions.—*Dallas Times*, May 15, 1921.

Taylor, Tex.—The appearance of a phosphorescent glow among the clouds first attracted the attention of the observer while watching the progress of a thunderstorm in the northeast. This glow became brighter shifting from the northwest to about due north and back again many times in rapid succession.

It resembled the light of a powerful searchlight, the summits of the cumuli being of silver brightness. The phenomena lasted for about 35 minutes, and occurred between 9.15 p. m. and 10 p. m.—*Taylor Democrat*, May 16, 1921.

Ajo, Ariz.—Ajo was treated Saturday night to a magnificent exhibition of the aurora borealis or northern lights.

The wonderful spectacle was first seen around 8 o'clock and was visible most of the time until a late hour.

Centering to the north, it extended as far in the sky as due west, and was even reported seen still farther south. After midnight it had spread to almost, if not quite, due east.

Various colors were displayed, including blood-red, blue, and orange. It appeared in detached portions, as well as in connected portions that extended clear across the sky. Faint rays or shafts of light were frequently seen extending from the horizon in the north clear to the zenith. The background resembled clouds or dense haze.

The changes were often like lightning, especially in the detached portions—no sooner had one seen the light here than it began to fade away, and in a few seconds was gone, only to appear in some other place. The night was perfectly clear, and the wonderful visitor was seen at his best.—*Ajo Copper News*, May 21, 1921.

Phoenix, Ariz.—The moving curtain of light made its appearance about 8 o'clock last evening, and continued intermittently until a late hour.

The aurora appeared in the northern sky, and extended from the eastern to the western horizon. The blaze varied continually in intensity, and moved across the sky, or brightened and faded, in a continually changing glory of light, through which the stars shone with undiminished brilliancy. At times there were three distinct lines of light, outlined like the lower edges of draperies, which grew brilliant and then lessened in intensity in an ever-varying degree of luminosity, while long streamers of faint light—the "rays" which northern observers have described in connection with the appearance of the aurora borealis—were dimly visible, extending from the streaks of light to the zenith.—*Arizona Republican*, May 15, 1921.

Tucson, Ariz.—A very fine display of the northern lights was observed here on Saturday night, May 14, to daylight Sunday morning. It was first observed at 8:30 p. m. and was most conspicuous in extremely bright patches here and there in the sky, lasting usually not over a minute, with large arcs crossing the northern horizon. It was slightly cloudy, especially overhead and toward the northeast, but bright patches of aurora could be seen in the west, and here and there groups of fine lines were visible, having always a slant of 60° from the horizontal, corresponding to the dip of the compass at Tucson.

The colors were a dull white, changing to a greenish tint in the northerly glows, a brilliant pearly luster in the patches and an occasional strong red color over large indefinite areas.

The display appeared to become somewhat less intense at 10:30 p. m., but shortly afterwards showed renewed activity, especially in long lines extending over large parts of the sky, which was now nearly clear, and all pointing toward a vanishing point of perspective situated about 30° south of the zenith and a little to the west of the meridian, which is the direction of our lines of magnetic force extending toward the South Pole. This vanishing point was very beautiful and was observed by many people. By 1 o'clock the display had somewhat diminished, but a later view at 3:30 showed a perfectly clear sky and the ordinary arcs crossing the northerly horizon with occasional nearly vertical streamers extending upward. This was observed in many other parts of Arizona and far exceeds the recollection of anything of the sort seen here in 40 years. I have notes on four previous occurrences. One was seen from Flagstaff, Ariz., in the winter of 1894-95, one was reported to me on November 5, 1916, and faint displays were seen here on October 9 and December 13, 1920. This was the first display of northern lights for most of the people of this part of the country.[3]—*Prof. A. E. Douglass*, Steward Observatory.

San Juan, Porto Rico.—Early Sunday morning, May 15, an aurora of unusual brilliancy was seen by many people of San Juan. It occurred after midnight (of the 14th) and lasted half an hour or more. The following description was given by Inspector of Police Doby, who in previous years had witnessed a number of auroras in northern Montana and was therefore quick to recognize this phenomenon which is so rare in Porto Rico. In fact, this was the first aurora seen here in 22 years.

Here is Mr. Doby's account: "The sky in the north was brightly alight and seemed filled with golden haze. Five great bars of extra brightness, extending from the horizon to the zenith, starting from a common axis, with diverging arcs about equal, extended through the golden haze and gave a wonderful effect."

Sunny Bank, Gordon Town, about 6 miles to northeast of Kingston, Jamaica.—On Saturday evening, May 14, at 10:40 p. m., the northern sky was filled to an altitude of 50° with a ruddy glow, which appeared something like the reflection of a tremendous bush fire, but approximated rather to a crimson color. At the same time shafts of orange light were projected from behind the hills, covering about 60° of the northern sky, in azimuth, and reaching an altitude of 40°. Each shaft of light was like the beam of a searchlight, its edges sharply defined, but was less diffused, i. e., the beam was of more nearly the same breadth throughout its length. The more remarkable feature was the constancy of the shafts of light. There was no movement noticeable during the 20 minutes or so during which they were under observation. At one time 16 shafts were counted over the space of about 60° in azimuth, and these remained steady for a considerable time.

This appears the more remarkable when we remember the latitude of observation 18° north.—*Lieut. A. W. Tucker.*

Negril Point Lighthouse, West Jamaica.—On Sunday, 15, at 12:45 a. m., a strange light from the north-northwest and north was seen by the keepers on the horizon. It was yellowish white, and resembled, from the description given, the aurora borealis or northern light. It was seen for some little time after 1 a. m. Sunday, but how long the keepers can not say, as it did not interest them very much, and they thought it may have been a searchlight.—*J. S. Brownhill, superintendent.*

Morant Point Lighthouse (to the east of Jamaica).—The aurora borealis was seen here on Sunday (15th) morning from 1 to 2 o'clock. There was a rosy flush in the northern sky, and at 1:20 a. m. the "lances of light" appeared, reaching upward to 50°, alternately fading and brightening until 2 a. m., when the aurora faded out.—*Chas. Durrant, superintendent.*

Carribean Sea, south of Cuba.—On the night of May 14 Lieut. Ostram, of the U. S. Navy tug *Montcalm*, observed a brilliant aurora.

British S. S. "Antillian" (Capt. W. E. Wood).—May 14, at 10 p. m., ship's time. Position, latitude 22° 07′ N., longitude 86° 33′ W. Course 541° true. Barometer 29.87 inches, temperature 79° F.; wind E. by N., 3; clouds A-cum. from southwest, amount 9. 9:50 p. m. observed peculiar color effect in sky in northeast direction from ship. Small portion of sky showed a decidedly reddish-brown color, which lasted about 10 minutes and resembled very much the reflection of a fire, except that light was steady and not flickering. From midnight on the 14th to 2 a. m. on the 15th sky to the north and northeast bright as though dawn was breaking, long streaks of light continually flashing, sometimes from about 20° altitude to the zenith. The streaks of light were parallel to each other, not radiating from a center. Color of sky in that direction similar to that reported earlier in the evening. Moon set at 12:30 a. m. This was apparently a display of aurora borealis.—*Observer A. T. Wood, third officer.*

Sinaloa, Mexico.—The northern light display of May 14 was very plainly visible from the mesa here—only a few miles from the Tropics. The Indians have been firing the forests to hasten the advent of the summer rains, and when I first observed the glow along the sky line formed by the Sierra Madre I thought they were indulging in their propitiation of the gods on a rather larger scale than usual. The glow began about 8 o'clock, and the rays were first visible about 15 minutes later. They were white to pale yellow in color, ever-changing in form, location, and brightness. Many of them appeared to reach an east-west great circle through the zenith, those low down in the eastern sky appearing longer. The apparent focus was several degrees east of north.[4]—*J. Gary Lindley.*

North Pacific Ocean.—News of a remarkable display of electrical phenomena last Saturday night, May 14, was brought to Honolulu to-day by Capt. E. Petterson, master of the Matson freighter *Hyades*, which arrived this morning from Puget Sound after a voyage of 12 days.

Capt. Petterson made public a letter which he has mailed to the local United States Hydrographic Survey for its information, and which describes the display as follows:

[3] Reprinted from *Science*, New York, July 1, 1921, p. 14.

[4] Reprinted from *Science*, New York, July 1, 1921, p. 14.

"May 14, at 8 p. m., in latitude 33.18 N., longitude 146.44 W., temperature 62, barometer 30.38. On this particular evening I observed numerous bright streaks which resembled the aurora borealis, in a north and south direction covering about two-thirds of the heavens and giving the northern portion of the sky a peculiar reddish tint.

"During this time the sky was very clear excepting the northern part close to the horizon. At 9:15 p. m. the streaks disappeared, leaving the north and eastern part of the sky very red for about 15 minutes, then gradually getting fainter until at 10:45 p. m., when it completely disappeared."

Capt. Petterson says the display was a magnificent one and that the rays resembled a great battery of searchlights, lighting up the clouds with a pure white color. The rays were white, but the sky was red. He says he has never seen anything like it in all the years he has been on the Puget Sound-Honolulu run.—*Honolulu Star-Bulletin*, May 19, 1921.

Apia, Samoa.—In the evening, between 6 and 7 p. m., a display of the aurora australis, a usual accompaniment of these magnetic disturbances, was observed. It was an extremely bright display, as otherwise it could not have been seen at all in the moonlight, and it is also a very rare event to see this phenomenon in latitudes near the equator. It is to be expected that news from the outside world will mention interference with the work of submarine cables and telegraphic work generally.—*Samoa Times*, May 28, 1921.

The following is a portion of a communication by Dr. A. L. Cortie in *Nature*, London, June 2, 1921, pp. 426–427.

On May 8 there appeared on the sun's eastern limb an equatorial sun spot in a region which has been without disturbance for some considerable time. It was an active spot which had separated by May 12 into two large spots. The maximum area of the group was 16.5, in units 1/5000 of the sun's disk, and this was attained on May 14. * * *.

The mean heliographic latitude of the earth during the passage of the group across the sun was $-2.8°$. Therefore, not only was there a large active sun spot on the sun, and with the penumbral character which frequently marks spots associated with magnetic disturbance, but also the earth was very favorably situated with regard to it. Under such conditions a great magnetic storm is inevitable.

WATERSPOUTS ON LAKE ONTARIO.[1]

By Ellis Gay.

[Pultneyville, N. Y., Aug. 5, 1921.]

I observed this phenomenon from Gates Grove, on lake shore about half way between Nine Mile Point and Pultneyville, Aug. 2nd. The weather conditions seemed peculiar—heavy cumulus clouds over the horizon, practically no wind; but about 9 a. m. a heavy swell from the northeast commenced, which I thought indicated a disturbance in that direction, although we could see no line of wind, as is often the case. About 11:30 a. m., I noticed on the eastern horizon what I thought to be the smoke of a steamer, "hull down," but could make nothing of it with the glass. As our eastern view is partially hidden by a point, I should guess that it was about off Pultneyville (5 miles). I paid no further attention to it for a few minutes (less than 10), when I again looked, it was directly in front of the cottage, almost due north. There was a smokelike disturbance on the surface of the lake of considerable size, and rising from it was a thin ribbonlike streamer which widened gradually until it was lost in the clouds. This streamer was visible *against* the low-hanging cumulus clouds which lay beyond it, as well as in the small portion of the horizon which was clear. As I could not tell how far away it was, there was no way of estimating the height of the cone, although I should guess it was 3 to 5 miles out and at least 1,000 feet high. (Other observers guessed a mile high.) Through glasses a rotation could be plainly discerned, and though there was a diversity of opinion, I am convinced that it was counterclockwise. The spout traveled from east to west at a good rate of speed, probably 40 to 60 miles per hour. While we were watching, another spout was formed approximately a mile from the first. I saw the column reaching down from the clouds finally touch the surface and make a disturbance similar to the original one. Later we saw a third column reach down; but it did not come to the surface. Two complete and one partial spout were visible at one time. They seemed to melt away when they were a few miles west of us. The duration of our observation was about five minutes. The sky in the west below the clouds showed a decided copper tint, and it looked as though there might be a thunderstorm somewhere north of Charlotte. The phenomenon had entirely disappeared at 12 m.

From all the data I have been able to find on the subject I am satisfied that we saw waterspouts.

[1] Waterspouts are rarely observed on the Great Lakes. The only previous spout on Lake Ontario of which there is a record occurred on Sept. 19, 1889. Spouts were reported on Lake Erie, off Buffalo Breakwater, Aug. 19, 1919.—Ed.

ANOTHER OBSERVATION OF WATERSPOUTS.

By Homer B. Benedict.

[Brockport, N. Y., Aug. 23, 1921.]

In the *Rochester Democrat & Chronical* for Aug. 5th, I saw an account of a waterspout seen on Lake Ontario east of Rochester on Tuesday, Aug. 2nd.

To corroborate the fact that such a phenomenon was seen, I wish to state that my family and myself saw such a waterspout or cyclone on this same date, over the lake about the middle of the forenoon, at my farm in the town of Hamlin, about twenty miles west of Charlotte.

My attention was first called to it by my son and others, calling to come out and see a strange cloud. When I reached the lawn I found all the members of the family collected, watching this mysterious cloud. It did not last long.

This cyclone cloud or waterspout, so-called, reached from the horizon line more than half way to the zenith. My first thought was a cyclone, for it was a very awe-inspiring sight and it seemed as if it might come towards where we were standing. Instead it moved westerly along the lake. At the point where it touched the water it looked as if smoke were arising from the water, which we decided was the water sucked up by the wind.

I do not believe that the cloud itself was composed of water, as it disappeared suddenly, without any mass of water falling into the lake, so far as we could see, but at the point where it touched the water there was evidently a great disturbance. One could imagine a great elephant's trunk, reaching from the sky to the water's surface. At the upper end it was funnel shaped or cone shaped, and then ran in a narrowing form to the water line. It was a swirling streak of cloud, and as we stood watching it, wondering what was to happen, it parted in the middle, part drawing into the clouds and the other gradually disappearing toward the lake; and then as if by magic it came together again in a narrower form, but still reaching from the water to a great height in the clouds. But all the while one could see what looked like smoke arising where the end of the cloud touched the water, and even when the cloudy pillar had disappeared the smoky spot could be seen traveling up the lake.

The day was rather sultry and the clouds looked like thunder caps.

Shortly after the cloud disappeared waves rolled in on the beach, showing that they had been tossed up by the wind, but on shore we had felt no unusual amount of wind.

I also read an account in some paper, I can not tell where, that Howard Palmer of Union Hill saw a similar cloud on this same day, which lasted fifteen or twenty minutes. As I said before, the one in front of our cottage lasted but a few minutes. I am told that there were others at Straight Lake who saw the cloud.

NOTES, ABSTRACTS, AND REVIEWS.

DEGREE OF PROBABILITY OF FORECASTS.

A foot-note attached to Mr. C. Hallenbeck's article in the MONTHLY WEATHER REVIEW for November, 1920, page 645, "Forecasting precipitation in percentage of probability," calls attention to the fact that a plan for expressing the degree of assumed reliability of a forecast numerically was suggested by Freiherr von Myrbach in 1913, and that a method of this character was used by the military meteorologists of the allied armies during the late war. It appears, however, that the history of such forecasts extends back much further. An ingenious mathematical method of predicting the percentage of probability of rainfall from the values of the principal meteorological elements at an observation hour is set forth in Dr. Louis Besson's article "Essai de prévision méthodique du temps, in Annales de l'Observatoire Municipal de Montsouris," volume 6, 1905, pages 173–495, which anticipates to a large extent the article by Dr. Bruno Rolf, Probabilité et pronostics des pluies d'été (Upsala, 1917). Moreover, a system of weighted forecasts was actually used by the official forecasters of western Australia from the beginning of the year 1905, as described by Mr. W. E. Cooke in the MONTHLY WEATHER REVIEW for January, 1906, pages 23–24. The question of adopting such a plan in the United States Weather Bureau has recently been under discussion.—*C. F. T.*

SOME SEVENTEENTH CENTURY IDEAS ABOUT THE WEATHER.[1]

By C. J. P. CAVE.

[Excerpted from *Quar. Jour. Royal Met'l. Soc.* Jan., 1920, 46: 65-68 (–87°).]

Pepys can not claim to be considered as a meteorologist; his references to the weather are such as anyone might make in writing a diary or in correspondence. Sometimes a month or more passes without any reference to the weather; when Pepys was with the fleet or going down the Thames by water references are more munerous, as might be expected. It should be noted that Pepys' memory for meteorological events was not always good, and his remarks on the worst or best weather he remembers must be taken with caution; for instance, he says that the night of July 13, 1667, was so hot that he lay with only a rug and a sheet over him, the first time certainly since he was operated on for stone (March 26, 1658), probably the first time since he was a boy; on July 15, 1668, it was so hot that again he lay with only a rug and a sheet over him, "the first night that I remember in my life that ever I could" do so.

The following is a short summary of the weather of the different years:

1660. The year began with a hard frost and snow; it thawed on January 10, but froze again in the middle of the month. From the end of March to the end of May, Pepys was with the fleet under Lord Sandwich, first in the Thames, then off Deal, and finally off the Dutch coast, whence the King was brought back to England. During this time weather notes are very numerous, but there is nothing very remarkable to record except very bad weather from the 11th to the 20th of May, with apparently an onshore wind at Scheveningen, which is recorded as being exceptional for the time of year. There is nothing very noteworthy during the rest of the year, except a few days' frost in the second half of November.

1661. The early part of the year was very warm; roses were in leaf on January 21, the roads were dusty, and many flies were about. February 19 is mentioned as "the first winter day we have had this winter," but even then it was raining, and there is no reference to frost or snow. On April 23, Coronation Day, there was a severe thunderstorm. May was wet, and by June 2 they began "to doubt a famine." There were slight frosts in the early part of December.

1662. The winter was again very warm, "which do threaten a plague," and January 15 was "a fast day ordered by Parliament to pray for more seasonable weather." There was a frost on the 26th, but apparently an isolated one. Some time just before February 25 there was a great gale which did widespread damage to trees. May was very fine and warm. The rest of the summer and autumn calls for no remark. On November 27 there was a fall of snow, "which is a rare sight, that I have not seen these three years." This was the beginning of a cold spell; there was skating in St. James's Park by December 1 and there was heavy snow on the 7th and 10th. On the 12th there was a sudden thaw, but there was still ice in the park on the 13th, when the Duke of York "would skate although the ice was dangerous." The thaw must have been both sudden and intense, as two of the Admiralty officials were nearly drowned on their way to Portsmouth.

1663. There was frost from February 1 or perhaps earlier, till the 13th, with skating in the park; then came "a monstrous thaw," and rain on the 17th. In March the weather was very changeable, with a thunderstorm on the 15th and sleet on the 29th. The beginning of May was very hot, with a thunderstorm on the 5th, which caused extensive floods near Northampton. The summer was very wet. Prior to June 30 the weather had been wet for "two or three months together," and on July 21 "Parliament kept a fast for the present unseasonable weather"; nor are there signs of any improvement later in the summer; on August 28 there was "a very great frost they say abroad, which is much, having had no summer at all almost." Early in December there was some frost and snow, but it became warm again on the 10th.

1664. This winter seems to have been exceptionally warm on the whole; a little snow on March 21 is contrasted with the general mildness of the previous months. The summer was remarkable for numerous thunderstorms; "there was more thunder this year than of any man's memory, and so it seems in France and everywhere else." On August 10 there was a great thunderstorm, "with such continuous lightnings, not flashes but flames, that all the sky and ayre was light; and that for a great while, not a minute's space between new flames all the time." Toward the end of December a frost set in.

1665. The frost continued till January 18, when it thawed, but it froze again, and on the 26th mention is again made of "a change of the weather from a frost to a great rain." There were frosts in February and March, and on March 26 Pepys says, "The last winter hath been as hard a winter as any have been these many years." This was the year of the great plague of London, but the summer appears to have been normal. On November 22 a frost began which lasted till the end of the month or later; it then seems to have been warm till December

[1] Quotations from the Diary of Samuel Pepys on the weather.

11 or 12, when a severe frost began; by the 18th the Thames was full of ice; on the 20th it was "troublesome" to cross by boat; on the 22d "the river is frozen," though Pepys visited the Duke of Albemarle by water on the 24th. On the 27th a thaw had set in, though there was still much ice on the river.

1666. On January 24 there was a very great gale. February and March seem to have been dry; on March 18 "all cry out for lack of rain." There was another drought later, for on June 26 we read of rain "after a long drowth." Several thunderstorms are reported during the summer, but there was another drought in August, for when the great fire began on September 2 Pepys says that everything was combustible after so long a drought. The general wind direction during the fire is seen from the entry for February 3, 1667, where it is recorded that pieces of burnt paper were carried by the wind as far as Cranborne near Windsor, which makes the wind direction between east-northeast and east. The drought continued till September 9. After this date the weather seems to have been very changeable; probably a westerly type prevailed till about December 10, after which it was frosty till the end of the year.

1667. The frost continued and the Thames was covered with ice on January 1. On January 9 it thawed. February seems to have been warm till about the 25th, when a cold spell began which lasted till the middle of March; on March 6 the King said that it was the coldest day he had ever known in England, and the 7th seems to have been still colder. The end of March and the first three weeks of April seem to have been dry and warm; on April 21 it rained, "it not having rained for many weeks." There seem to have been a good many days of easterly wind in June and July, which helped the Dutch when they came up the Thames; the month of July was dry till the 27th. The rest of the year calls for no special remark, except that no frost is mentioned, though November 10 was "mighty cold."

1668. There seems to have been no hard frost or snow this winter. March was mostly fine and dry with a drought that ended on April 4. On May 22 there was a heavy rain in London and to the north, but none at Newmarket; the rainfall must have been very heavy, as it caused floods near London, at Cambridge, and at Brampton in Huntingdonshire. The end of September and the beginning of October seem to have been exceptionally fine and warm, "as good as summer in all respects." There was frost on December 7, but it seems to have been unusually warm during most of December, as Pepys says that he only put on a waistcoat at night on December 24, "the first winter in my whole memory that ever I staid till this day before I did so."

1669. The early part of January was frosty and there was snow on the 13th. There are no weather entries for February, but the end of March was cold, with several falls of snow.

The diary ends on May 30 of this year.

* * * * *

The Duke of York, afterwards James II, seems to have been something of a meteorologist, for on April 4, 1668, he told Pepys his rules for knowing the weather, and he apparently made a very good forecast on that day, but Pepys does not tell us what his rules were.

It may be interesting to note that the sounds of distant gunfire were frequently heard in London. On the first four days of June, 1666, guns were plainly heard in London when the English and Dutch fleets were engaged off the North Foreland. On June 2 Pepys went "into the parke, and there we could hear the guns from the fleete most plainly," and later in the day he told the King and the Duke of York, and they also went into the park to hear the guns. But though heard in London they were not heard on the coast; the *Katherine* yacht saw the Dutch fleet on May 29, ran from them, and came up the Thames on June 2, having heard no firing at all. Evelyn heard the guns near London and went down to the coast, but found that nothing had been heard at Deal. On June 4 Pepys writes: "So walking through the parke we saw hundreds of people listening at the Gravell-pits, and to and again in the parke to hear the guns, and I saw a letter, dated last night, from Strowd, governor of Dover Castle, which says that the Prince [Rupert] come thither the night before with his fleete, but that the guns which we writ that we heard, it is only a mistake for thunder; and so far as to yesterday it is a miraculous thing that we all Friday, and Saturday and yesterday, did hear everywhere most plainly the guns go off, and yet at Deale and Dover to last night they did not hear one word of a fight nor think they heard one gun. This added to what I have set down before the other day about the *Katherine*, makes room for a great dispute in philosophy, how we should hear and they not, the same wind that brought it to us being the same that should bring it to them; but so it is." All this is quite in accordance with the audibility of gunfire in recent years.

On July 25th the fleets met again in the North Sea, and when Pepys went to Whitehall he was told that in the park "the guns are heard plain." Many went into the park, and the King and the Duke of York went into the bowling green and upon the leads, to hear the guns; Pepys joined them, and "it was pretty to hear how confident some would be in the loudnesse of the guns, which it was as much as ever I could do to hear them."

EXTRAORDINARY DUST STORM IN NORTH DAKOTA.[1]

By LEONARD P. DOVE and OTHERS.

[Abstract.]

That wind is a major agent[2] in moving material and fashioning the present earth features would seem self-evident, but seldom does the process intrude itself in a such a striking way as in the recent (Jan. 18–19, 1921) storm in North Dakota.

The storm in question, which apparently originated in Nevada and eventually covered an approximate area of 400,000 square miles, reached Grand Forks, N. Dak., on the 18th of January. On that morning the ground in North Dakota was partially snowcovered. During the afternoon clouds of dust began to arrive and soon collected in thick layers on the snow surface. A thaw set in during the next morning and by 10 a. m. was followed by a light rain which cleared the air and preserved the dust from further removal. On the night of the 19th another light snowfall occurred, and this in turn was followed by a slight thaw. Thus it became an easy matter to collect very complete dust samples. These samples were screened and then examined under a microscope. The greatest bulk of the material was probably of local origin. The finer particles were probably kept in suspension by the wind and brought down by the rain mostly to the eastward. The cinders are no doubt from the

[1] The dust storm of 1921. *Quarterly Jour. of the Univ. of N. Dak.*, vol. xi, No. 3, April, 1921.

[2] Keyes, Charles Rollin. Competency of wind in land depletion. MO. WEATHER REV., Feb., 1917, 45: 57–58.

railroad tracks and yards. Fibers of plants and considerable humic material were mixed with the dust. The amount of dust in the caked mud would increase the total that would pass the 200-mesh screen to approximately 90 per cent. Assuming these samples to be representative the amount of dust deposited on each square mile would equal the astonishing total of 801 tons.—*H. L.*

RAIN-MAKING AGAIN!

[Reprinted from *Nature*, July 21, 1921, p. 659.]

The popular fallacy that explosions can precipitate rainfall found expression in the question asked by Maj. Morrison-Bell in the House of Commons on July 13 as to whether the Government would be prepared to initiate experiments which might possibly have the result of precipitating a downpour of rain. The answer given was to the effect that from past experiments meteorologists were of the opinion that explosions would not induce a fall of rain, and rightly so; for experiments were conducted on a vast scale, not, it is true, with that particular end in view, on the western front during the Great War. The collation of statistics of rainfall with the gunfire failed to show any certain connection. The only way in which the water vapor in the atmosphere can be condensed into clouds is by cooling. Unless an explosion can produce a cold current, or cause to any appreciable extent such a disturbance in the atmosphere as will bring about the mixture of a stratum bearing a cold current with that carrying a warmer current, it can not produce rain. The compression in the air produced by a bursting shell is propagated as a sound wave. The amplitude of the motion, therefore diminishes as the square of the distance from the origin, so that at the distance of a quarter of a mile it would probably be no greater than one ten-thousandth of an inch. In 1917 M. Angot, Director of the French Meteorological Office, showed that in the extreme case of two equal masses of saturated air, one at 0° C. and the other at 20° C., it would be necessary, in order to produce rain of even so small an amount as 1 mm. (0.04 inch), for the two masses rapidly and thoroughly to mix throughout an atmospheric layer of 6,850 meters (about 4 miles) in thickness. Nor are dust particles and ions, which form the nuclei of raindrops, sufficient of themselves to cause precipitation unless there be a concomitant reduction of temperature.

CORRECTION OF A MARINE BAROMETER FOR ERRORS DUE TO SWINGING.

By W. G. DUFFIELD and T. H. LITTLEWOOD.

[Abstracted from *London, Edinburgh, and Dublin Philosophical Magazine*, July, 1921, pp. 166-173.]

A swinging barometer, such as is used in gravity determinations and for meteorological purposes on shipboard, is subject to two sources of error as a result of the swinging. First, the effect of small oscillations about the point of support tends to make the reading too high. Second, the swinging about the point of support tends to make the reading too low because of the action of the centrifugal force in the mercury. The purpose of the investigation was to so arrange the barometer that these two errors, which are of opposite sign, would exactly neutralize each other. This adjustment may be made either by keeping the point of suspension fixed, which will keep the distance from the center of oscillation to the center of gravity constant, and make such adjustments to the barometer as will change the length of an equivalent simple pendulum; or, by altering the point of suspension, thus changing both of the lengths mentioned above. In the latter case, the point must be found where the required relationship is attained. In a marine barometer upon which tests were made, it was found that practice agreed closely with theory, and, for that particular instrument, the error was zero when the period of oscillation was about 1.66 seconds (first method); and (second method) when the center of oscillation was 21.5 cm. below that used in the first method. The authors recommend that all marine barometers, whether they are to be used merely for meteorological purposes or for more precise gravity work, should be so constructed as to permit of these adjustments.—*C. L. M.*

CLOUD FORMATION BY SUPERCHARGED PLANE.[1]

[Reprinted from *U. S. Air Service*, July, 1921, p. 13.]

An altitude flight was made in the morning at McCook Field [Dayton, Ohio] recently, by Lieut. J. A. Macready in a La Pere with supercharged Liberty. When the airplane reached a height of 26,000–27,000 feet at 11:50 a. m., a long feathery white streamer was observed forming behind a rapidly moving dark speck. The cloud was of the cirrus variety, well defined at its edges and apparently 10 to 15 times the width of the plane. The sky behind the first portion was clear blue with no other clouds in the near neighborhood. The first streamer seemed perhaps 2 miles long. Then a gap of one-quarter mile. The second streamer formed with a background of light cirrus cloud and after 2 or 3 miles the plane seemed to go into the cirrus background, for the streamer formation ceased while an apparent path of blue continued beyond for a way in the cirrus cloud. The whole streamer may have been 3 miles long. After 20 minutes the streamer had drifted and spread until it merged indistinguishably with the other cirrus clouds visible. The weather conditions at the time were generally very clear, warm, with perhaps 0.1 of the sky in cirrus clouds. * * *

[1] Cf. Varney, B. M.: The Argonne battle cloud. Mo. WEATHER REV., June, 1921, 49: 348-349, also Wegener, A.: Frost-supersaturation (Frostübersättigung) and cirrus. *Ibid.* p. 349.

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SOLAR OBSERVATIONS.

SOLAR AND SKY RADIATION MEASUREMENTS DURING JULY, 1921.

By HERBERT H. KIMBALL, Meteorologist.

[Dated: Solar Radiation Investigations Section, August 31, 1921.]

For a description of instruments and exposures, and an account of the method of obtaining and reducing the measurements, the reader is referred to this REVIEW for April, 1920, 48: 225.

The monthly means and departures from normal of Table 1 indicate that solar radiation intensities were close to normal intensities for July at Lincoln, Nebr., and Santa Fe, N. Mex., above normal at Madison, Wis., and decidedly below normal at Washington, D. C. The hazy condition at Washington, mentioned in connection with the June radiation measurements, continued into July, being particularly marked with the cloudless skies of the 5th and the 8th. It was an upper haze, as on the 8th mountains 30 miles distant were distinctly visible.

Table 2 shows that the total radiation received from the sun and sky was close to normal at both Washington and Madison, except at Washington during the week beginning July 9, which was unusually cloudy. A feature of the Callendar pyrheliometer record for this week at Washington was a trace showing zero radiation between 3 p. m. and 4 p. m., July 15, during a heavy thunderstorm. At this time it was so dark that work indoors was impossible after the electric lighting plant ceased to function. The daylight appeared to be less intense than at the end of civil twilight with a clear sky.[1]

Skylight polarization measurements made at Madison on seven days give a mean of 65 per cent with a maximum of 70 per cent on the 21st. These are close to average July values for Madison. At Washington, measurements obtained on four days give a mean of 38 per cent, with a maximum of 51 per cent on the 28th and a minimun of 7 on the 8th. All these values are below the July averages for Washington.

TABLE 1.—*Solar radiation intensities during July, 1921.*

[Gram-calories per minute per square centimeter of normal surface.]

Washington, D. C.

Date.	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon.
	75th meridian time.	Air mass. A. M.					P. M.				Local mean solar time.
	e.	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e.
	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
July 5	19.23					0.63					21.28
8	20.57				0.21	0.60					19.23
18	16.20			0.57	0.79	1.09	0.84	0.66			14.10
21	12.24		0.69								11.81
25	18.59				0.85						14.60
26	16.79		0.50	0.60	0.79	0.97					14.10
27	17.96	0.50	0.60	0.75	0.98	1.29					19.23
28	18.59				0.98						19.23
Means		(0.50)	0.60	0.64	0.77	0.92	(0.84)	(0.66)			
Departures		−0.09	−0.10	−0.18	−0.14	−0.28	−0.13	−0.10			

[1] Kimball, Herbert H.: The duration and intensity of twilight. MO. WEATHER REV., November, 1916, vol. 44, diagram, p. 619.

* Extrapolated.

TABLE 1.—*Solar radiation intensities during July, 1921*—Continued.

Date.	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon.
	75th meridian time.	Air mass. A. M.					P. M.				Local mean solar time.
	e.	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e.
Madison, Wis.											
	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
July 1	16.20				0.97						15.6
7	19.89					1.13					17.95
9	15.11			0.97							14.60
10	15.11		0.84	0.99	1.10	1.23					10.59
11	15.11			0.90	1.08	1.29					13.13
12	17.37	0.56	0.65	0.80		1.22					16.20
15	14.60					1.21					12.24
16	14.60		0.74	0.85		1.28					11.81
19	13.13				1.16						12.24
20	11.81		0.78	0.94	1.14	1.38	1.16				8.18
21	11.38		0.91	1.02	1.15	1.27	1.05	0.89			9.47
27	18.59					1.25					18.59
28	14.10					1.37					15.11
30	15.11				1.02	1.34					15.11
Means		(0.56)	0.78	0.92	1.09	1.27	(1.10)	(0.89)			
Departures		−0.07	+0.02	+0.04	+0.07	+0.02	+0.11	−0.01			
Lincoln, Nebr.											
July 7	16.20					1.32	1.16	1.02	0.88		22.00
8	10.97							0.99	0.86		13.61
9	15.11			0.98	1.14						13.13
11	16.79			0.92	1.06	1.23					13.61
15	16.79			0.93	1.07	1.22					15.65
16	11.60				1.17		1.08	0.80	0.77		14.60
19	15.65			0.97	1.15	1.36		0.93	0.77		15.65
20	15.11		0.76	0.95	1.13	1.28					13.61
21	14.60						0.96	0.69			13.61
25	14.10				0.85						16.79
27	17.37			0.96			1.06				17.37
29	16.20				1.03	1.26					20.57
Means			(0.76)	0.95	1.08	1.28	1.06	0.89	0.82		
Departures			−0.04	+0.05	±0.00	−0.06	−0.01	±0.00	−0.07		
Sante Fe, N. Mex.											
July 9	7.57		0.99	1.13							7.29
12	8.48				1.20						9.14
13	8.48		0.92	1.07	1.24	1.44					9.83
14	9.83		0.83	1.08	1.24						10.97
16	9.83		0.94	1.12	1.29						10.59
29	8.81		0.98	1.12	1.22						9.83
Means			0.93	1.10	1.24	(1.44)					
Departures			−0.01	+0.02	+0.02	+0.02					

* Extrapolated.

TABLE 2.—*Solar and sky radiation received on a horizontal surface.*

Week beginning—	Average daily radiation.			Average daily departure for the week.			Excess or deficiency since first of year.		
	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.
	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.
July 2	535	545		+ 22	+ 5		+417	−4,596	
9	373	606		−129	+71		−483	−4,098	
16	583	536		+ 92	+17		+164	−3,980	
23	535	460		+ 55	−36		+548	−4,232	

MEASUREMENT OF THE SOLAR CONSTANT OF RADIATION AT CALAMA, CHILE, JUNE, 1921.

NOTE.—The above report, having been delayed in transmission from Chile, will appear in the next issue of the REVIEW.—EDITOR.

WEATHER OF NORTH AMERICA AND ADJACENT OCEANS.

NORTH ATLANTIC OCEAN.

By F. A. YOUNG.

The average pressure for the month of July was somewhat above the normal at land stations on the American coast and in the British Isles. It was considerably higher than usual at Swan Island, West Indies, and slightly below normal at St. Johns, Newfoundland, and the Azores.

The number of days on which fog was observed was apparently not far from the normal over the greater part of the ocean.

July is usually the quietest month of the year over the North Atlantic, and the month under discussion was no exception to the general rule, as winds of gale force were not reported on more than two days in any 5° square.

On the 1st there was a well-developed LOW central near latitude 45° N., longitude 42° W., the storm area covering a limited region, with northwest winds of a maximum force of 9 in the southwesterly quadrants.

The storm log from the Danish S. S. *Frederick VIII* is as follows:

Gale began on June 30, wind E. Lowest barometer 29.31 inches at 6 a. m. on the 1st, wind WNW., 9; position, latitude 45° 07′ N., longitude 43° 20′ W. End of gale on the 1st, wind NNW. Highest force of wind 9, WNW.; shifts not given.

From the 2d to the 14th the conditions were comparatively featureless, with light to moderate winds prevailing over practically the entire ocean, except that a few isolated reports were received indicating moderate gales on the 2d and 3d in the mid-section of the southern steamer lanes.

On the 15th a LOW surrounded Nova Scotia and Newfoundland, and moderate westerly gales were encountered in the southerly quadrants, between the 37th and 42d parallels. Storm log from the British S. S. *Strathearn* is as follows:

Gale began on the 14th. Lowest barometer 29.98 inches at 2:10 a. m. on the 15th, wind WSW., 6; position, latitude 40° 09′ N., longitude 69° 58′ W. Same reading at 2 a. m. on the 17th, wind WSW, 8; position, latitude 40° 12′ N., longitude 58° 18′ W. End on the 17th. Highest force of wind 10, WSW.; shifts WSW.-SW.

On the 15th there was also a moderate disturbance central near latitude 47° N., longitude 17° W. There were no Greenwich mean noon observations from that locality indicating a wind force of more than 6, although the Belgian S. S. *Gothland* encountered a northwesterly gale a little later in the day, as shown by the following storm log:

Gale began on the 15th, wind WNW. Lowest barometer 29.77 inches at noon on the 15th, wind WNW, 8; position, latitude 48° 08′ N., longitude 22° 04′ W. End of gale on the 16th, wind W. Highest force of wind 8, WNW.; steady from WNW.

On the 16th and 17th the British S. S. *Strathearn*, as shown by her storm log given above, reported a moderate southwesterly gale near latitude 40° N., longitude 58° W. The storm area must have been extremely limited, as vessels in the immediate vicinity experienced only moderate winds.

From the 18th to the 22d there was a second period of inactivity over practically the entire ocean, with uniformly high pressure and weak gradients, although on the 22d and 23d the land station at Lerwick, Scotland, reported westerly winds of about 50 miles an hour. The extent of this disturbance could not be determined, as no ship reports for these dates and that locality have as yet been received. Charts IX and X show the conditions for the 24th and 25th, respectively. Storm logs follow:

Danish S. S. *Arkansas:*

Gale began on the 24th, wind NE. Lowest barometer 29.16 inches at 10 a. m. on the 24th, wind N., 10; position, latitude 53° 57′ N., longitude, 28° 45′ W. End of gale on the 25th, wind N. Highest force of wind 11; steady from N.

British S. S. *Strathearn:*

Gale began on the 24th, wind SSW. Lowest barometer 29.67 inches at noon on the 24th, wind NW., 8; position, latitude 48° 50′ N., longitude 24° 50′ W. End of gale on the 25th, wind WNW. Highest force of wind 8, shifts SSW-W-WNW.

At Greenwich mean noon on the 27th moderate weather prevailed over the entire ocean, but the following storm log from the American S. S. *Cotati* shows that a disturbance developed shortly afterwards over the eastern section of the steamer lanes:

Gale began on the 27th; wind SSE. Lowest barometer 29.29 inches at 12:15 p. m. on the 27th, wind SSE., 5; position, latitude 44° 48′ N., longitude 17° 24′ W. End at midnight of the 27th, wind W. Highest force of wind 11; shifts not given.

On the 28th and 29th conditions were somewhat similar to those of the 27th, as at Greenwich mean noon no heavy weather was reported, with the exception of the disturbance over the British Isles that will be referred to later, while intermittent gales were encountered in mid-ocean as shown by the following storm logs:

British S. S. *Winnebago:*

Gale began on the 28th, wind W. Lowest barometer 29.64 inches at 1 a. m. on the 31st; wind WSW., 8; position, latitude 46° 55′ N., longitude 30° 55′ W. End of gale on August 1st, wind NNW. Highest force 8; shifts WSW.-NNW. This gale was practically continuous with the wind at force of 7 to 8. In the time between gales the wind never moderated below force of 5 to 6.

American S. S. *Blair:*

Gale began on the 28th, wind W. Lowest barometer 29.86 inches at 6 p. m. on the 28th. Wind SW., 5; position, latitude 38° N., longitude 49° 15′ W. End of gale on August 1, wind SW. Highest force 8, SW.; shifts not given.

On the 29th there was a well-developed LOW central near London. The storm log from the American S. S. *Hattie Luckenbach* that was near the center on that date follows:

Gale began on the 29th, wind W. Lowest barometer 29.56 inches at 4 a. m. on the 29th, wind SW., 9; position, latitude 51° 10′ N. longitude 1° 43′ E. End of gale on the 29th, wind WNW. Highest force of wind 9; shifts SSW.-SW.-W.-NW.

On the 30th and 31st moderate southwesterly gales swept a limited area between the 35th and 42d parallels and the 55th and 63d meridians. The storm log from the American S. S. *Westwego* follows:

Gale began on the 29th, wind SW. Lowest barometer 29.88 inches, at 2 a. m. on the 31st, wind SW., 7; position, latitude 39° 57′ N., longitude 58° 35′ W. End of gale on the 31st. Highest force of wind 8 shifts WSW.-NNW.

NORTH PACIFIC OCEAN.

By F. G. TINGLEY.

Pressure at Dutch Harbor was generally, though not continuously, above normal during the first half of the month, the daily excess being approximately 0.15 inch. The highest pressure, 30.34 inches, occurred on the 4th and 5th. During the latter half it was below normal by an average of about 0.28 inch. The lowest pressure,

29.26 inches, was recorded on the 26th, being 0.86 inch below the normal for that date. At Midway Island pressure was below normal during the first week by a daily average of 0.08 inch and above normal thereafter, except on the 19th, by an average of 0.07 inch. At Honolulu pressure was very generally below normal during the first half of the month and above during the last half, the departures as a rule being small.

The month opened with a typhoon forming in the region to the eastward of the Philippines. On the 4th this typhoon passed a few miles to the north of Manila, thence across the China Sea and the Gulf of Tongking, entering Tongking on the 7th.[1]

The opening days of the month also witnessed a northwesterly gale off the California coast of the United States, due to the southeastward movement of the high pressure area noted at Dutch Harbor on the 4th and 5th. Reports of this gale from vessels that were involved are as follows:

British S. S. *Ben Venue*, Capt. C. Marsh, Observer D. McGiep, Portland (June 30) for Panama.

Gale began on the 1st, wind N. by W.; lowest barometer 29.87 inches at 5 a. m. of 2d in latitude 37° 53′ N., longitude 123° 53′ W., wind NNW., 9; end of gale on 2d, wind NNE.; highest force 10, NNW.; shifts, N. to WNW.

American S. S. *Stockton*, Capt. S. Rustad, Observer G. Flyeum, Los Angeles (June 30) for Honolulu.

Moderate gale from NNW. set in at 8 p. m., June 30, hauling to N. by noon of July 1 and continuing for next 20 hours; wind then hauled to NE., force 7–8; a large sea, shifting with the change of wind, was running and vessel shipped the heaviest seas recorded in 10 months' service across the Pacific. Barometer at noon (G. M. T.) on 30th, 29.77 inches, noon of 1st, 29.94 inches. Position on latter date, latitude 32° 47′ N., longitude 124° 40′ W.

American Bark *Moshula*, Capt F. O. Parker, Newcastle (Australia), via Manila, for San Francisco.

July 1, latitude 38° 25′ N., longitude 130° 24′ W., hard gale set in from N. and continued until the 3d; on the 2d reached force 11, NNW., with a heavy sea; on 3d split foresail; position on 3d, latitude 33° 34′ N., longitude 128° 05′ W. Barometer remained high during gale.

The American Army transport *Buford*, Capt. L. R. M. Kerr, Observer Oscar A. Littchen, Honolulu for San Francisco, was involved in this gale from the afternoon of the 1st to the morning of the 3d. The wind reached force 8, from the NW. Postition at noon (G. M. T.) on 2d, latitude 36° 46′ N., longitude 125° 53′ W.

From the 9th to the 11th the U. S. revenue cutter *Bear*, Capt. C. S. Cochran, Observer R. T. McElligott, experienced a southeasterly gale while cruising in Alaskan waters. Following is the report from the *Bear:*

Gale began on the 9th, wind SE.; lowest baromater 29.70 inches at 6 p. m., same date, in latitude 65° 57′ N., longitude 170° 06′ W. end of gale on the 11th; highest force of wind, 9, SE.; shifts, 4 points.

On the 21st and 22d (Asiatic time) the Japanese S. S. *Korea Maru*, Capt. M. Jin, Observer H. Shimmura, Yokohama for Honolulu, had a moderate to fresh easterly gale. This was near latitude 30° N., longitude 177° E.–177° W. Highest force of wind 8, ESE.; lowest barometer 29.87 inches, at 4 p. m. of the 21st, in latitude 30° 20′ N., longitude 179° 20′ E.

On the 14th a second typhoon formed in the region between the Philippine Islands and Ladrone Islands, whence it moved in a northwesterly direction through the Balintang Channel, the China Sea, and the northern part of the Gulf of Tongking.

An unusual amount of fog was reported during the month by vessels on the northern steamship routes.

TWO TYPHOONS OVER THE PHILIPPINES, JULY 4 AND 22, 1921.

By JOSÉ CORONAS, S. J., Chief, Meteorological Division.

[Weather Bureau, Manila, P. I., July 30, 1921.]

Two well-developed typhoons have visited the Philippine Islands during this month of July—one near Manila on July 4, and the other through the Balintang Channel near the Batan and Babuyan Islands on July 22.

Typhoon of July 4.—This typhoon was hardly shown by the observations of Guam and Yap. It is only with very slight probability, based on the winds prevailing at Yap in July 1, that we may suppose that the typhoon was formed on that day between 14° and 15° latitude N. and in about 132° or 133° longitude E. It seems, however, certain that it did not form east of the meridian 135°, but rather to the west of same. In other words this typhoon belongs to the type of those that form nearer to the Philippines than to the Ladrone Islands. As the extent of the typhoon was rather small, its existence could not be noticed in our weather maps until the morning of July 3, when the first warnings were issued by Manila Observatory. The approximate position of the center at 6 a. m. of the 3d was 126° longitude E. and 14° 30′ latitude N.

The center of the typhoon passed a few miles to the north of Manila moving almost due west at 1:45 p. m. of July 4, when the barometric minimum 745.50 mm. (29.35 inches) was recorded. A gale from NW. backing to SW. and S. blew for about six hours (from 11 a. m. to 5 p. m.) doing considerable damage to the city. The highest velocities of the wind recorded in the most violent gusts were 75 miles per hour at 1:28 p. m., and 63 miles per hour at 1:53 p. m. No vortical calm was observed in Manila, but relative calm lasting from 20 minutes to 1 hour was reported from practically all the towns situated from 5 to 25 miles north of Manila. The greatest damage of the storm was done to the Provinces of Rizal, Bulacan, Pampanga, and Bataan. The center traversed Tayabas Province near Polillo and Infanta, the northern part of Rizal Province, the southern part of Bulacan, Pampanga, and Zambales Provinces, and the northern part of Bataan Province. The rate of progress of the typhoon while crossing the Philippines was 8 miles per hour.

In the China Sea, the typhoon increased its rate of progress and inclined northwestward, thus crossing the Paracel Islands in the morning of the 6th, and traversing the Gulf of Tongking and entering Tongking on the 7th.

Typhoon of the "Naugus:" July 22.—We call this the typhoon of "*Naugus*" because this steamer was almost caught in its center in the China Sea, July 23, with a barometric minimum as low as 715 mm. (28.15 inches). The position of the "*Naugus*" at noon of the 22d was 21° 30′ latitude N. and 118° 54′ longitude E., and at noon of the 23d, 18° 59′ latitude N. and 116° 44′ longitude E. The barometric minimum was observed at 8 a. m. of the 23d. The steamer was on her way from Dairen to Batavia; all the superstructure, life boats, and ventilators were damaged, but the hull and the machinery remained intact.

The steamer "*Loong Sang*," on her way from Hongkong to Manila, felt also the fury of the storm in the China Sea, the barometer having fallen to 735.57 mm. (28.96 inches) at 4 p. m. of the 23d.

[1] See article below regarding typhoons of July, 1921, by Rev. José Coronas, S. J.

This typhoon was formed on the 14th of July between 11° and 12° latitude N., and between 132° and 133° longitude E. It moved first slowly to WNW., then on the 16th it inclined NW. and NNW. between 130° and 127° longitude E., and 12° and 14° latitude N. After having moved almost due north on the 17th and 18th, it remained nearly stationary for over two days between 126° and 125° longitude E., and between 19° and 20° latitude N., at the same time recurving to W. The rate of progress during these two days was only of about 1.5 miles per hour. Finally, on the 21st the typhoon moved W. toward the Balintang Channel, and on the 22d it passed between the Batan and the Babuyan Islands with a rate of progress of about 9 miles per hour. As there is no telegraphic communication with these islands, no news has reached Manila as yet of the great damage supposed to have been done there by the storm. The approximate position of the typhoon was at 6 a. m. of the 22d 20° latitude N. and 121° 30′ longitude E.; and at 6 a. m. of the 23d, 19° 30′ latitude N. and 117° 30′ longitude E.

In the China Sea, it moved for a while even with a little inclination to WSW. The northern part of the Gulf of Tongking was crossed by the typhoon on the 25th; it was moving then WNW.

[Year 1921, ship Loong Sang; Capt. A. F. Simpson; observer, master; month, July; voyage from Hongkong to Manila.]

Day.	Hour.	Port or position.		Barometer.		Wind.		Clouds.		Sea.		Remarks.
		Latitude N.	Longitude (Greenwich) E.	As read off.	Att. ther.	Direction.	Force 0-12.	Forms by symbols.	Moving from.	State by symbols.	Direction from which coming.	
22	5 p. m.			29.51	91	wsw.	1	Cum.-str		2	E	Easterly swell.
22	8 p. m.	21° 48′	114° 40′	29.55	88	se.	3	...do...		2	E	Do.
22	12 p. m.	21° 15′	115° 00′	29.52	87	ne.	5	...do...		4	E	Swell increasing.
23	1 a. m.			29.50	83	ne.	7	...do...	ne.	4	E	Do.
23	4 a. m.	20° 40′	115° 15′	29.39	83	n.	7	...do...	ne.	5	E	Typhoon traveling west by Barocyclonometer.
23	5 a. m.			29.36	84	n.	8	Nim	n.	6	E	Set in rain showers.
23	7.30 a. m.	20° 00′	115° 30′	29.30	84	n.	9	...do...	n.	6	E/N	Heavy rain and wind squalls.
23	9 a. m.			29.27	84	n/w.	9	...do...	n.	7	E/N	E/N swell and high sea from north.
23	10 a. m.			29.18	83	nnw.	10	...do...		8	ENE	ENE. swell and high sea from north.
23	11 a. m			29.15	82	nnw.	10	...do...		10	ENE	ENE. swell and high sea from north (typhoon D's. W/S).
23	Noon	19° 12′	115° 30′	29.10	82	nw/n.	10	...do...		10	ENE	Very heavy rain squalls.
23	2 p. m.			28.98	81	n/w.	11	...do...		10	NE. and NW	Very confused cross seas.
23	4 p. m.	18° 50′	115° 40′	28.96	81	wsw.	11	...do...		10	W	Lost NE. swell. Terrific squalls.
23	6 p. m.			29.05	80	sw.	11	...do...		9	SW	Sea more regular.
23	7 p. m.			29.13	80	sw.	11	...do...		8	SW	Squalls decreasing in force and number.
23	8 p. m.	18° 30′	116° 05′	29.20	80	sw.	11	...do...		8	SW	
23	9 p. m.			29.30	80	sw/w	10	...do...		8	SW/W	Weather improving.
23	10 p. m.			29.40	80	sw/w.	7	...do...		7	SW/W	Do.
24	6 a. m.	17° 30′	117° 10′	29.50	83	ssw.	4	Str.		5	Southerly	
24	10 a. m.			29.61	84	ssw.	4-5	...do...		4	SSW	

NOTES ON WEATHER IN OTHER PARTS OF THE WORLD.

British Isles.—London, July 10.—England is sweltering and suffering in the worst drought in a century.

To-day was the seventy-eighth virtually rainless day. The entire countryside is baked hard. For the third successive day temperatures have exceeded 100. * * * The rainfall for the year is less than one-third normal to date.—*Washington Herald*, July 11, 1921.

London, July 24–30.—The general character of the weather underwent a great change during the week, and before the end rain fell in most districts, more especially in Scotland and Ireland.—*Weekly Weather Report of the Meteorological Office.*

France.—Paris, July 12.—The Senate yesterday adopted a resolution providing for cancellation of the usual July 14 military review in Longchamps, owing to the extreme heat.—*Washington Times*, July 12, 1921.

Paris, July 19.—Reports to-night indicate that abundant rain has fallen over almost all France, and that the hot spell is effectively broken.—*Philadelphia Public Ledger*, July 20, 1921.

Germany.—Berlin, July 27.—* * * The potato crop has been the hardest hit of any in Germany by the prolonged dry weather, and unless heavy rains come within the next few days there is likely to be a shortage of this mainstay of German diet during the coming winter.—*Brooklyn Eagle*, July 27, 1921.

Switzerland.—Zermatt, July 26.—* * * The heat has not greatly abated. On the summit of the Wellenkuppe, above Zermatt, and 12,830 feet high, the temperature at 10 o'clock in the morning has exceeded 100° F., and this despite the summit's being perpetually snowclad. * * * One climber describes the summit of the Weisshorn as looking like a carpet worked with the most beautiful colors. Never do Alpinists remember such a variety of bright-colored butterflies in the high mountains as this year. * * * Seldom, indeed, have climbers been more exposed to the danger of avalanches, especially snow avalanches, than this season.—*New York Times*, July 27, 1921.

Italy.—Venice, July 30.—The principal phenomenon which prevailed [this week] was the intensely hot weather. An unprecedented heat wave continued to develop in its intensity of heat and in the length of its duration. For several weeks the heat has increased until the past week the temperature has been high up in the nineties for day after day, and unofficial reports of temperatures of over 100° have been frequent. The extremely high humidity has practically brought active business to a standstill, and has caused many deaths and heat exhaustions. * * *

The principal damage caused by the heat wave is the protracted period of drought which accompanies it. Agriculture is the chief sufferer from the heat and drought, and no alleviation appears in sight. Weeks of cloudless, scorching days have played havoc with the crops which were in progress when the heat wave began. The vegetable crop as well as the fruit and early fall crops are showing the effects of the unseasonable heat and drought.—*From U. S. Consul at Venice.*

Russia.—Berlin, July 17.—Twenty million persons are on the verge of starvation in drought-stricken sections of Russia, subsisting mainly on moss, grass, and the bark of trees, according to the *Vossische Zeitung*, which quotes information from "reliable Russian sources." * * *

The parched earth, it is asserted, is opening up great crevices, and wells and rivers are drying up. Foliage is asserted to have withered on the trees, and a number of villages are reported on fire.—*Worcester Telegraph*, July 18, 1921.

Philippine Islands.—Manila, July 5.—A typhoon today caused heavy damage in Manila and its environs.[1]

The city's power supply was cut off, and the city was in darkness. Houses were unroofed and several small vessels in Manila Bay driven ashore. Street-car service was paralyzed.—*New York Tribune*, July 5, 1921.

[1] See report by Coronas, this REVIEW, p. 417.

DETAILS OF THE WEATHER OF THE MONTH IN THE UNITED STATES.

GENERAL CONDITIONS.

By A. J. HENRY.

The period of high temperature in the United States and Canada evidently culminated in the current month with positive departures at individual stations of as much as 10° and 12° F.—a remarkably large abnormality for a summer month. (See Chart IV of this REVIEW.) Drought continued in the Lake region, the Mississippi and Ohio Valleys, and locally in the Middle Atlantic and New England States. The rainfall was in excess of the average in the South Atlantic and East Gulf States, particularly along the Atlantic coast from Wilmington, N. C. to Jacksonville, Fla.

Pressure was slightly above normal in practically all parts of the country, especially over the Canadian Maritime Provinces and the States of Washington and Oregon where the ocean HIGHS seemed to extend their influence over the continent.

CYCLONES AND ANTICYCLONES.

By W. P. DAY, Observer.

Low pressure areas were numerous with frequent developments over the western Plateau region; however, few reached storm intensity and several disintegrated after a short existence.

Pressure was high continuously during the month over the Atlantic Ocean in the vicinity of Bermuda and off the Pacific coast. The North Pacific HIGH frequently invaded the extreme Northwestern States and most of the migratory HIGHS originated there and drifted eastward and southward. None of the high pressure areas charted were important.

Tables showing the number of HIGHS and LOWS by types follow:

Lows.

	Alberta.	North Pacific.	South Pacific.	Northern Rocky Mountain.	Colorado.	Texas.	East Gulf.	South Atlantic.	Central.	Total.
July, 1921	5.0	......	......	......	6.0	......	1.0	2.0	1.0	15.0
Average number, 1892-1912, incl.	4.8	0.7	0.3	0.5	0.9	0.2	0.1	0.1	1.0	8.6

Highs.

	North Pacific.	South Pacific.	Alberta.	Plateau and Rocky Mountain Region.	Hudson Bay.	Total.
July, 1921	4.0	....	2.0	1.0	2.0	9.0
Average number, 1892-1912, incl.	1.3	0.3	3.0	1.2	0.8	6.6

NOTE 1.—Henceforth in plotting the paths of low pressure areas on Chart III, secondary developments will be given the designation, "A," "B," etc., in their order of appearance or development from the parent LOW. Further developments from secondaries will carry the designation of the secondary and the lower case letters "a," "b," etc. in the order of occurrence.

THE WEATHER ELEMENTS.

By P. C. DAY, Climatologist and Chief of Division.

[Weather Bureau, Washington, D. C., Sept. 1, 1921.]

PRESSURE AND WINDS.

Probably the most significant feature of the atmospheric pressure distribution during the month was the persistent high pressure over the far Northwest. The pressure is normally high during the summer season over the Pacific coast districts from central California northward to Washington, but there are usually periods when it becomes relatively low, due to the passage inland of cyclonic areas from the Pacific. During July, 1921, pressure was constantly above 30 inches along the coast of Oregon and Washington, and even further inland the average for the month was the highest of record. As a result no storms entered the country from that region and local weather changes were unimportant during the entire month. Over the Southeastern States pressure was likewise higher than normal due to the extension of the North Atlantic HIGH further westward than usual into that district. This preponderance of pressure in southern districts, so persistent during the present year, and a tendency exhibited by low areas to pursue their eastward courses near the Canadian border, favored a continuation of southerly winds and warm weather over many of the central and northern districts from the Rocky Mountains eastward.

Areas of low pressure developed rather frequently over the Plateau and Great Plains districts, but they usually weakened in their eastward courses and soon disintegrated. The HIGHS entered the country mostly as weak offshoots from the permanent high area over the Pacific Northwest. As they moved slowly eastward in rather low latitudes they brought only slight daily changes in pressure, and lacked the coolness that usually attends the movement of HIGHS southward from the Canadian Provinces.

For the month as a whole pressure was above normal in all portions of the country, save locally in central California, and along the Canadian border.

As a result of the usual slight variations in pressure the winds were comparatively light, save in connection with the occurrence of thunderstorms or other types of summer storms. From the Plateau and Rocky Mountain districts eastward, the prevailing winds were from southerly points, and these directions were maintained locally over long periods. In the far West, as a result of the continued high pressure over Washington and Oregon they were mainly from northerly points.

TEMPERATURE.

In the absence of marked changes in barometric pressure during the month, temperature showed a corresponding stationary condition and there were few important changes. The persistent warmth that has marked the present year to date over much of the interior and northern parts of the country, and that became so pronounced during the latter half of June, particularly in the great central valleys, continued without a material break

throughout that region till the end of the month. In the vicinity of the Great Lakes the temperature continued above the normal daily from early in June till the 30th of July, a period of time unsurpassed in the history of the Weather Bureau for that or probably any other section of the United States. In other portions of the country, particularly in the far West, the temperatures were less uniform, notably during the first week of the month, when it was moderately cool to westward of the Rocky Mountains, and during the second and third weeks, when cool weather prevailed over the Southwest. The last decade of the month had moderately cool weather in most Southern States, and the last week had weather somewhat cooler than normal over most districts from the Rocky Mountains westward.

Maximum temperatures above 100° were observed at some period during the month in practically all portions of the country, save where influenced by proximity to large bodies of water, or over elevated regions. The maximum for the month, 123°, was observed in southern California, and temperatures as high as 110° were observed at points in the southern Plateau and northern Plains.

In the far western districts the coolest weather was experienced near the beginning of the month, when temperatures below freezing were observed at nearly all high stations. In the districts to the eastward the coolest weather was confined mostly to the last decade, and the last day of the month was the coolest over the upper Mississippi Valley and Lake region.

The average temperature for the month as a whole was above normal in practically all central and northern districts, the area of greatest excesses being located over the upper Mississippi Valley and Lake region, where they ranged from 6° to 12°. In portions of this area the month was the warmest of record during the period of Weather Bureau observations, more than 50 years, and this tendency toward an excess of heat has been maintained for many months. At Chicago, Ill., July was the eleventh consecutive month with average temperature above normal, the excess since the first of the present year amounting to more than 8° per day, a condition which has not previously existed in the history of that station.

Over the Southwest and generally along the Pacific coast, and in the extreme Southeast the month was slightly cooler than normal.

PRECIPITATION.

The precipitation for the month as a whole was fairly generous over most of the country where appreciable amounts usually occur in midsummer, but the distribution was irregular as to both occurrence and amount. Over the Great Plains from Texas, Oklahoma, and Kansas northeastward and eastward to the Great Lakes and Middle Atlantic States, the average precipitation was nearly everywhere decidedly less than the normal July fall, and considerable areas had but little precipitation at any time during the month. Similar conditions prevailed over the region from the northern Rocky Mountains westward to the Pacific, where the fall was likewise much less than normal. Over portions of the east Gulf and South Atlantic States the precipitation was in excess of the average, and at a few points in this region the monthly amounts were the greatest of record for July. In the Dakotas and Nebraska the monthly falls were slightly in excess, and they were above normal in portions of Arizona, New Mexico, and adjacent States.

The precipitation was mainly from thunderstorms, as is usual for midsummer, but there was a marked absence of conditions favoring the occurrence of such storms over extensive areas at the same time.

SNOWFALL.

Early in the month local snows were reported from points in the Plateau and Rocky Mountain regions. At Yellowstone Park a total depth of nearly 4 inches was reported on the 3d and 4th, the greatest of record for July. On the 9th a summer snowstorm of unusual severity was reported from points in the mountains of southwest Colorado.

RELATIVE HUMIDITY.

Over the central valleys and Great Lakes where unusual heat and partial drought conditions prevailed during the month, the relative humidity, as might be expected, was decidedly less than normal, and similar conditions prevailed in the far Northwest, where there was likewise a well marked deficiency in precipitation. Along the Atlantic coast relative humidity was generally above normal, particularly over portions of New England, where at points it averaged the highest of record for July. It was likewise high over much of the Great Plains and southern Mountain and Plateau regions.

NOTE.—Details regarding severe wind, rain, and hail storms will be found in the table following.

Severe local storms.

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the Annual Report of the Chief of Bureau.]

Place.	July.	Time.	Width of path.	Loss of life.	Value of property destroyed.	Character of storm.	Remarks.	Authority.
			Yards.					
Ellendale, N. Dak	2	P. m			$600,000	Thunderstorm	Storm of wide extent; estimated loss in South Dakota $200,000.	Official, U. S. Weather Bureau.
Aberdeen, S. Dak	2	P. m		1	350,000	Tornado	Wire communication interrupted, 9 injured	Journal of Commerce (N. Y.).
Petersburg, Ind). 3 miles west of).	4	8 p. m	7,040			Wind and hail	Considerable damage to crops, windows, roofs	Evansville Courier (Ind.).
Peoria, Ill. (north of).	4	P. m				do	Damage to grains and telephone lines	Chicago Journal.
Flint, Mich	5	P. m				Wind, rain, and hail	Damage by floods, trees blown down, small buildings unroofed, traffic suspended.	Evansville Courier (Ind.).
Rockport, Ind	5	5 p. m	5,280		40,000–50,000		Heavy damage by lightning and floods. Traffic suspended.	Do.
Owensboro, Ky	5	3 p. m				Wind and rain	Damage to buildings, trees, etc	Do.
Maryville, Mo., and vicinity.	6	6 p. m				Wind and hail	Damage to trees, crops, houses, wires. Poultry killed.	Democrat Forum (Maryville, Mo.).
Grand Rapids, Mich.	6	P. m				Wind, rain, and hail	Severe general damage, traffic interrupted	Official, U. S. Weather Bureau.
Taylor, Tex	6	P. m	1,760			Wind and rain	Velocity of wind 40 to 62 miles. Crops and houses damaged.	Austin American (Austin, Tex.).
Hornell, N. Y., and vicinity.	7	P. m				Wind and hail	Damage to grains	Star-Gazette (Elmira, N. Y.).
Ludington, Mich. (near).	7	P. m				Wind, hail, and rain	Great damage to truck, field crops, trees and buildings. Live stock killed.	Ludington Daily News (Mich.).
Cleveland and northern Ohio.	8	P. m		11		do	Cellars flooded, heavy property damage, wires down, 12 injured.	Plain Dealer (Cleveland, Ohio).
Syracuse, N. Y., and vicinity.	8			2	100,000	Thunderstorm	Damage to crops, public utilities equipment, and farm buildings.	Brooklyn Eagle (N. Y.).
Oneonta, N. Y	8			2		Electrical	Church damaged	Do.
Shelter Island, Long Island.	9					Hail and electrical	Small damage done	Do.
Boston, Mass., and vicinity.	9			1		Electrical	Washouts, railway and trolley lines submerged, damage by lightning.	New York Times.
Greenville, S. C. (20 to 25 miles north of).	11					Hail	1,000 acres of crops suffered severely	Official, U. S. Weather Bureau.
Hagerstown, Md., and vicinity.	11	P. m				Thunderstorm	Crops and wires damaged. Lightning struck barn, destroying contents valued at $6,000.	Washington Post (D. C.).
Scobey, Mont., and vicinity.	11–12					Wind and hail	Severe damage to crops, barns and granaries wrecked, poultry killed.	The Independent (Helena, Mont.).
Williston, N. Dak. (north and east of).	11–12					Hail	Considerable damage to grains and buildings	Herald (Williston, N. Dak.).
Malta, Mont	12	4 a. m	3,520			Wind and hail	Crops on approximately 20 farms damaged from slight to total.	Great Falls Tribune (Mont.).
Antelope, Mont., and vicinity.	12	4 p. m				Hail	Most severe storm in 25 years; much damage	Do.
Amos and Cottonwood, Mont.	12		1,760			do	Considerable damage	Promoter (Havre, Mont.).
Harlem, Mont	12–13		3,520			Hail and rain	All crops in path of storm destroyed	Great Falls Tribune.
Great Falls, Mont	13					Hail, wind, and rain	Flood and wind caused considerable damage to buildings and crops.	Montana Record (Mont.). Herald (Great Falls).
Black Eagle, Mont	13					Hail	Severe damage to grain	Washington Herald (D. C.).
Lansing, Mich. (north and south of).	14					Wind and rain	General damage done	State Journal (Lansing, Mich.).
Ilion, N. Y., and vicinity.	14					Cloudburst	Heavy damage to crops; 1 to 3 feet of water in some sections.	Washington Herald (D. C.).
Middletown, N. Y	15					Electrical	Severe damage to grain; 8 cows killed	New York Herald.
New York City and vicinity.	15					Thunderstorms	Much damage by lightning; buildings flooded	Brooklyn Eagle.
Rockaway Beach	15			1		Wind	Small boat upset	Do.
Gulchull, N. Dak	16		1,760			Tornado	5 persons injured; houses and barns destroyed	Chicago Daily News.
Fargo, N. Dak	26	P. m				Cloudburst	Heavy crop damage	Washington Herald (D. C.).
Camp Edwards, Sea Girt, N. J.	26	P. m				Wind	Camp wrecked, tents, buildings, and trees blown down.	New York Times.
Bellville, N. J	26				35,000	Wind and electric	Amusement equipment, buildings, trees, poles, blown down.	Do.
Detroit, Mich	27					Wind and rain	Slight damage done	Official, U. S. Weather Bureau.
Terre Haute, Ind	28	P. m				Electrical	Damage to poles, trees, etc	Do.
Indianapolis, Ind	28			1		do	Man killed by live wire	Terre Haute Star (Ind.).
Paris, Ill	28	P. m				Wind and rain	Traffic blocked	Do.
Williamstown, Mass., and vicinity.	28	4 p. m				Wind and electric	Considerable damage done to trees	Boston Herald.
Newburyport, Mass.	28	P. m				do	2 cottages carried to sea; several persons injured	Do.
Portland, Me., and vicinity.	28	P. m				Thunderstorm	Considerable loss to telephone system. Lightning destroys home, barn, and stock.	Do.
Suffield, Conn. (west of). }	28				{ 300,000 400,000 }	Hail and wind	100,000 acres of tobacco ruined	Do.
Hartford, Conn. (near).	28					Thunderstorm	Considerable damage	Official, U. S. Weather Bureau.
Memphis, Mich	29		6,160			Hail		Do.
Toledo, Ohio	29					Wind and rain	Trees uprooted, wires down, pavements washed up.	Toledo Times (Ohio).
Nashville, Tenn	31					Wind	Minor damage	Official, U. S. Weather Bureau.
Cairo, Ill	31				7,000	Thunder and wind	Maximum velocity of wind 60 miles	Do.
Chattanooga, Tenn. (near).	31	P. m				Wind and rain	Loss by wind large	Chattanooga Times (Tenn.).
Nantucket, Mass	31	P. m				Electrical	Minor damage done	Official, U. S. Weather Bureau.
Bennington, Vt	31					Hail	No details	Do.

STORMS AND WEATHER WARNINGS.

EDWARD H. BOWIE, Supervising Forecaster.

WASHINGTON FORECAST DISTRICT.

The month of July was not unlike the month immediately preceding it, in that the eastward trend of weather changes was perceptibly slower than usual for summer months, cyclones were few and of slight intensity and those charted moved across the continent along the Canadian border or well to the northward. The development of the subpermanent HIGH over the North Atlantic was abnormal, and its westward extension beyond the shore line of the United States was one of the marked features of the pressure distribution of this and the preceding month. Consequently the month was abnormally warm and the rainfall largely from local thundershowers and thunderstorms in the Washington forecast district. No storm warnings were ordered for the Atlantic and east Gulf of Mexico coasts, and none were required. The weather on the Great Lakes was unusually quiet during the month and storm warnings were required on only one occasion. In that instance, severe squalls and strong south to west winds occurred.

In the West Indies and over the Gulf of Mexico, the northeast trade wind held sway, and there was at no time any indication of a tropical storm in these regions.

CHICAGO FORECAST DISTRICT.

No special warnings were issued from the Chicago district during the month of July. The month was abnormally warm throughout most of the district and usually free from disturbances other than local in character.—*E. H. Haines.*

NEW ORLEANS FORECAST DISTRICT.

The month was free from stormy weather, except for a few local thunderstorms. No warnings were issued or needed.

During the second week the rainfall was due largely to a weak depression which moved slowly westward near the Gulf coast from the 3d to the 10th. This depression, though slight and moving abnormally, was persistent, and the rainfall which set in after it reached the middle Gulf coast continued after it had merged with the semipermanent depression in the arid Southwest. There were no other features worthy of special note.—*R. A. Dyke.*

DENVER FORECAST DISTRICT.

No important barometric areas crossed the district during the month, and no special warnings were issued except on the morning of the 3d, when low barometer readings prevailed in New Mexico and relatively high pressure in the Plateau region. Warnings of local frost were issued for Utah and northern Arizona. Frost temperatures, with clear skies, were reported in the valleys of northern Arizona on the morning of the 4th, but the barometer fell in northwestern Colorado and northern Utah and a rise in temperature occurred in Utah.—*Frederick W. Brist.*

SAN FRANCISCO FORECAST DISTRICT.

July was a quiet month in this district, no storms from the north Pacific passed far enough south to materially affect the weather. A few light storms of the Sonora type formed over the valley of the Colorado and thence moved east or northeast causing scattered light showers and thunderstorms in portions of the Plateau, the southern Sierra, and the mountain regions of southern California. The only one of these of importance, was that of the 20th, in the mountains back of San Diego, when heavy rain accompanied with high shifting winds caused a rapid rise in the small mountain streams and did some damage to crops. During this storm 2.90 inches of rain fell at Campo in less than an hour, and it was estimated that the rainfall was heavier in the higher mountains.

High temperatures were frequent throughout the interior but there was much cool weather and fog near the coast.

Fire-weather warnings were issued in northern California on the 1st and 2d.

Small-craft warnings were displayed from Eureka to Point Reyes on the 2d and 3d.—*G. H. Willson.*

RIVERS AND FLOODS.

By H. C. FRANKENFIELD, Meteorologist.

[Weather Bureau, Washington, Aug. 26, 1921.]

Atlantic drainage.—Heavy rains fell over the drainage basin of the Santee River during the late afternoon of July 17 and the night following, and on the morning of July 18 flood warnings were issued for the Santee, lower Wateree, and lower Congaree basins. The crest stage in the Santee River was slightly more than 1 foot above the average flood stage of 12 feet, although no damage was done. About $10,000 worth of cattle and hogs were driven from the swamps before the floods occurred.

There was also a rapid rise in the Ocmulgee River about the same time which was covered by adequate warnings.

Mississippi drainage.—Rises were unimportant except in the Arkansas River from Wichita, Kans., westward and in the upper Canadian River. Warnings for the Arkansas River were first issued on July 21, and bank-full stages occurred generally between July 15 and 25. Losses amounted to about $3,500, and about $2,000 worth of property in the State of Kansas was saved through the warnings.

Pacific drainage.—The annual rise of the Columbia River reached its close during the month of July, and the following report thereof was prepared by Mr. R. C. Mize, meteorologist, Portland, Oregon:

Reports at the close of March indicated that the amount of snow remaining in the higher mountains was above normal in eastern Oregon; slightly above normal in Idaho, northwestern Wyoming, and western Montana; about normal in British Columbia, and somewhat below normal in Washington. The snow was unusually compact, and the soil generally unfrozen and filled with water. At this time warning was given that, should a decided warm period occur in late May or in June, the river would rise considerably above the flood stage. This warning was generally heeded and little planting done below the 25-foot level except where the land was under dike.

The only great loss in any one section was due solely to the breaking of a portion of the dike in district No. 5 near Woodland, Wash., the

resulting damage totaling approximately $220,000, or nearly one-third of all the reported damage from the flood. Very little direct damage was done within the city of Portland, the principal loss being the cost of moving goods, pumping water from basements in the business section, and cleaning up after the flood.

The Snake River reached its crest at Lewiston May 20, and at Weiser May 23, but did not commence to fall rapidly until the crest was reached in the upper Columbia shortly before the middle of June. Flood stages were not reached on the Snake River, nor at Umatilla, Celilo, or Cascade Locks on the Columbia. The backwater in the Willamette River at Portland reached the flood stage May 17, three days earlier than the average, and fell below the flood stage on July 10, one day later than the average. The crest, 24.3 feet, was 0.1 foot below the one-day forecast, 0.2 below the two-day forecast, and 0.4 below the three-day forecast. Summaries of flood data and loss and damage are given below. The number of acres affected is greater than the number reported.

Flood data for 1921 and comparative data.

Station.	River.	1921.				Comparative data.				
		Flood stage.	Duration days.	Crest height.	Date of crest.	Highest record.	Average date of crest.	Average height of crest.	Mean June, 1921.	June normal.
Weiser	Snake	14	0	13.6	May 23	26.5	June 1	11.5	10.5	8.6
Kamiah	Clearwater	14	10	15.4	May 20					
Lewiston	Snake	22	0	19.1	May 20	26.6	May 30	16.0	14.1	11.5
Bonners Ferry	Kootenai	26	14	27.9	June 10	32.7	June 11	24.7	24.7	20.8
Newport	Pend Oreille	16	31	19.8	June 13	24.9	June 12	16.0	18.2	....
Marcus	Columbia	24	56	32.1	June 13	33.8	June 23	30.5	30.4	....
Wenatchee	do	40	19	44.4	June 11–12	58.0	June 14	38.2	41.3	33.9
Umatilla	do	25	0	24.8	June 10–11	34.5	June 9	21.5	22.1	18.3
Celilo	do	30	0	21.9	June 11	23.4			18.8	14.9
The Dalles	do	40	10	42.4	June 11	59.6	June 12	36.7	37.4	....
Cascade Locks	do	46	0	33.9	June 11	49.6	June 11	28.8	29.4	23.3
Vancouver	do	15	55	25.2	June 12				22.9	18.2
Portland	Willamette	15	54	24.3	June 12–13	33.0	June 11	20.3	22.1	17.6

Highest summer stages, Willamette River, Portland, Oreg.

Year.	Feet.	Year.	Feet.	Year.	Feet.	Year.	Feet.	Year.	Feet.
1876	28.2	1887	25.7	1896	23.8	1905	13.6	1914	16.8
1879	20.5	1888	18.2	1897	23.7	1906	13.4	1915	12.6
1880	27.3	1889	10.0	1898	20.7	1907	19.2	1916	23.9
1881	19.7	1890	20.1	1899	24.2	1908	21.2	1917	23.8
1882	25.1	1891	14.1	1900	17.8	1909	21.6	1918	19.2
1883	17.8	1892	19.3	1901	20.8	1910	19.1	1919	18.6
1884	20.2	1893	22.0	1902	20.8	1911	19.2	1920	14.8
1885	14.5	1894	33.0	1903	24.0	1912	19.7	1921	24.3
1886	20.0	1895	16.3	1904	20.8	1913	24.0	....	....

Statistics of money loss by flood.

Kind of loss or damage.	In Portland.	Outside.	Total.
Buildings, etc	$30,505	$99,975	$130,480
Crops		57,600	57,600
Prospective crops (acres 13,965)		318,790	318,790
Movable property		1,650	1,650
Suspension of business	9,123	140,404	149,527
Total	39,628	618,419	658,047
Saved by warnings	121,625	481,030	602,655

MEAN LAKE LEVELS DURING JULY, 1921.

By UNITED STATES LAKE SURVEY.

[Detroit, Mich., Aug. 4, 1921.]

The following data are reported in the Notice to Mariners of the above date:

Data.	Lakes.*			
	Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during July, 1921:	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Above mean sea level at New York	602.59	580.44	572.90	246.37
Above or below—				
Mean stage of June, 1921	+0.16	−0.14	−0.12	−0.24
Mean stage of July, 1920	−0.28	−0.59	+0.27	+0.67
Average stage for July, last 10 years	+0.05	−0.53	+0.05	−0.42
Highest recorded July stage	−1.23	−3.14	−1.51	−2.35
Lowest recorded July stage	+1.11	+0.54	+1.44	+1.78
Average relation of the July level to:				
June level	....	+0.10	0.00	0.00
August level	....	0.00	−0.20	+0.30

* Lake St. Clair's level: In July, 575.62 feet.

Floods during month of July, 1921.

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
ATLANTIC DRAINAGE.					
Santee:	*Feet.*			*Feet.*	
Rimini, S. C.	12	18	18	12.2	18
Do	12	20	27	13.3	24
Do	12	30	30	12.1	30
Ferguson, S. C	12	19	29	13.0	26,27
MISSISSIPPI DRAINAGE.					
Big Pigeon:					
Newport, Tenn	6	21	21	6.5	21
Missouri:					
St. Charles, Mo	25	(*)	5	26.0	1
Grand:					
Brunswick, Mo	10	(*)	8	12.4	3
Arkansas:					
Fort Lyon, Colo	6	19	19	6.7	19
Canadian:					
Logan, N. Mex	8	21	21	15.0	21
Sulphur:					
Finley, Tex	24	(*)	5	27.6	1
Ringo Crossing, Tex	20	(*)	1	21.0	1
Neches:					
Rockland, Tex	20	12	16	21.0	13
Trinity:					
Liberty, Tex	25	(*)	4	26.0	1,2
COLORADO DRAINAGE.					
Colorado:					
Parker, Ariz	7	(*)	15	9.6	1
Yuma, Ariz	25	(*)	1	25.0	1
PACIFIC DRAINAGE.					
Columbia:					
Marcus, Wash	24	(*)	16	29.2	1
Vancouver, Wash	15	(*)	10	18.9	1
Willamette:					
Portland, Oreg	15	(*)	9	18.1	1

* Continued from June.

EFFECT OF WEATHER ON CROPS AND FARMING OPERATIONS, JULY, 1921.

By J. WARREN SMITH, Meteorologist.

[Weather Bureau, Washington, D. C., Aug. 29, 1921.]

Weather conditions throughout the month of July were generally favorable for outdoor activities in all sections of the country, except that near the close haying and harvesting were delayed by rains in local areas, particularly in the Northeast. Until the last few days of the month, temperatures remained unseasonably high over practically all of the country from the central and upper Rocky Mountains eastward. The month was cooler than normal in the extreme Southeast and parts of the Southwest, while frosts were reported during the first week in the Northwest. While some crops suffered from heavy to excessive rainfall in a few places, in parts of the Great Central Valleys and some Atlantic coast districts the month was almost rainless until the closing days, causing, with the heat, conditions which proved very damaging. Corn suffered severely in much of the Ohio and central Mississippi Valleys, although rain near the end of the month greatly improved its condition in much of this region. Harvest of corn was in progress in Texas at the close, with favorable results.

The harvesting of winter wheat was practically completed during the month, weather conditions being exceptionally favorable for this work in most districts. Thrashing also made excellent progress. The warm and dry weather the first of the month was unfavorable in most of the spring-wheat belt, where the crop matured too rapidly, and yields, where harvesting was accomplished, were disappointing. Oats and barley also suffered from unfavorable weather conditions.

Potatoes developed fairly well in northeastern districts, but deteriorated in all sections where dry weather and unusual heat prevailed, until the close of the month when cooler weather and good rains benefited the crop greatly.

In the cotton belt temperatures were generally about normal until the latter part of the month, when they exceeded the normal, and most sections received sufficient moisture, except that portions of the more western Gulf States were too dry, and locally in the central and extreme eastern areas an unfavorable amount of moisture was reported, causing shedding and an increase of weevil activity as well as grassy fields.

Pastures and meadows were unfavorably affected by dry weather in interior sections of the country and in some upper Plateau districts, but very beneficial rains received in the southern Plateau areas and in other portions of the far Southwest during the last half of the month, greatly improved the grazing areas.

Citrus fruits were generally favorably affected by the weather, although there was considerable orange drop in California. Deciduous fruits made good advance in the West and Northwest.

CLIMATOLOGICAL TABLES.*

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, July, 1921.

Section.	Temperature.								Precipitation.					
	Section average.	Departure from the normal.	Monthly extremes.						Section average.	Departure from the normal.	Greatest monthly.		Least monthly.	
			Station.	Highest.	Date.	Station.	Lowest.	Date.			Station.	Amount.	Station.	Amount.
	° F.	° F.		° F.			° F.		In.	In.		In.		In.
Alabama	81.4	+1.5	6 stations	103	4†	Greensboro	59	24	5.17	−0.34	Ozark	9.54	Cochrane	1.10
Arizona	80.1	−0.4	Maricopa	116	1	Fort Valley	34	5	4.19	+1.70	Soldier Camp	15.79	Aztec	0.09
Arkansas	82.0	+2.2	2 stations	107	4†	Dutton	54	23	2.42	−1.43	Fulton	5.46	Ozark	0.30
California	74.0	0.0	Greenland ranch	123	1†	Portola	24	10	0.05	+0.01	Campo	5.30	186 stations	0.00
Colorado	66.8	+0.5	Lamar	105	2	Crested Butte	17	5	2.72	+0.36	Palisade Lake	5.96	Crested Butte	0.52
Florida	80.5	−0.7	Bonifay	101	31	Griffin	63	3	8.33	+1.43	Brodentown	20.60	Hypoluxo	2.44
Georgia	79.9	−0.2	Rome	103	31	Blue Ridge	58	23	6.90	+1.13	Waycross	19.39	Lisbon	2.76
Hawaii (June)	74.6	+1.5	2 stations	92	2†	Volcano Observatory	51	22	1.96	−2.70	Wahiawa Mountain	9.91	9 stations	0.00
Idaho	67.8	+0.6	2 stations	109	7†	Bostetter R. S	22	3	0.35	−0.43	Rice	1.85	14 stations	0.00
Illinois	80.7	+4.8	Mascoutah	105	13	Sycamore	47	22	1.84	−1.57	Morrisonville	8.10	Mount Vernon	0.12
Indiana	80.4	+5.1	2 stations	104	4†	Wheatfield	48	22	2.18	−1.27	Cambridge City	4.67	Marion	0.77
Iowa	77.9	+3.8	Clinton	104	11†	New Hampton	41	31	2.53	−1.43	Thurman	7.45	Mason City	0.42
Kansas	79.2	+1.1	Norwich	108	30	St. Francis	50	4	3.13	−0.37	Plains	9.50	Wichita Evaporating Sta.	0.19
Kentucky	81.1	+4.4	Hopkinsville	106	3	Jackson	52	22	2.64	−1.66	Middlesboro	6.81	2 stations	0.34
Louisiana	82.4	+0.8	Calhoun	105	5	Calhoun	62	8†	6.60	+0.35	Amite	12.85	Grand Cane	2.52
Maryland-Delaware	77.7	+2.6	Frederick, Md	101	27	Oakland, Md	45	23†	4.22	−0.23	Ferry Landing, Md	8.80	Frederick, Md	1.06
Michigan	75.6	+7.0	Mio	108	4	Deer Park	37	31	2.60	−0.62	Ironwood	8.32	Mount Pleasant	0.20
Minneosta	74.2	+5.1	2 stations	103	1†	Taylors Falls	36	31	3.62	0.00	Sandy Lake Dam	6.49	Albert Lea	0.35
Mississippi	82.4	+1.7	4 stations	104	5†	Booneville	62	21	4.56	−0.61	Hattiesburg	11.19	Batesville	1.53
Missouri	80.3	+2.9	Caruthersville	109	17	Bolivar	46	22	2.32	−1.77	Brunswick	5.60	Seymour	0.43
Montana	67.1	+1.5	Billings	110	20	Bowen	24	3†	1.38	0.00	Highwood	5.60	Big Ox	0.00
Nebraska	76.4	+1.8	2 stations	104	3†	Harrison	38	3	4.08	+0.67	West Point	9.47	Bridgeport	0.64
Nevada	74.2	+1.6	Logandale	114	1†	Vya	27	3	0.19	−0.16	McGill	1.92	18 stations	0.00
New England	72.4	+3.0	Van Buren, Me	107	3	Van Buren, Me	39	17	4.79	+1.10	Boston, Mass	11.69	Woodland, Me	0.97
New Jersey	76.5	+2.8	Vineland	99	4	Charlotteburg	43	23	3.62	−0.99	New Brunswick	7.36	Paterson	1.66
New Mexico	70.4	−1.4	Carlsbad	110	18	Red River Canyon	29	11	4.41	+1.66	Harveys Upper Ra'h	9.65	Cundiyo	0.79
New York	74.9	+5.3	Brockport	103	8	Homestead San't'm	39	22	4.28	+0.36	Cortland	9.51	Buffalo	1.42
North Carolina	77.6	+1.1	3 stations	101	31	Banners Elk	49	23	5.53	−0.57	Southport	16.02	Chapel Hill	1.00
North Dakota	71.4	+3.9	2 stations	110	9	2 stations	35	30†	3.04	+0.43	Larimore	10.00	Taylor	0.37
Ohio	77.8	+4.2	3 stations	103	4†	2 stations	49	22	2.93	−1.03	Peebles	8.80	Lima	0.45
Oklahoma	81.2	+0.4	Cleveland	106	30	Kenton	52	11	2.49	−0.60	Broken Bow	7.04	Tulsa	0.17
Oregon	65.6	−1.0	Harper	104	19	Lapine	19	3	0.12	−0.50	Pendleton	0.98	38 stations	0.00
Pennsylvania	75.9	+3.9	Bethlehem	104	4	2 stations	45	16†	4.13	−0.03	Cresson	9.19	Driftwood	1.23
South Carolina	79.6	−0.2	Calhoun Falls	101	30	Aiken	60	15†	7.44	+1.50	Charleston	7.58	Gaston Shoals	2.21
South Dakota	75.0	+3.8	Jefferson	109	9	Elk Mountain	33	3	3.29	+0.76	De Smet	8.99	Lemmom	0.71
Tennessee	80.2	+2.9	3 stations	104	6†	Mountain City	47	23	4.73	+0.15	Sewanee	9.00	Brownsville	1.40
Texas	82.9	0.0	Rossville	108	24	Clint	52	1	2.31	−0.42	Pierce	8.94	7 stations	0.00
Utah	72.1	+1.2	St. George	109	7†	St. John	20	2	1.05	+0.01	2 stations	3.51	3 stations	0.00
Virginia	77.5	+1.8	Hopewell	101	8	Burkes Garden	45	24	3.96	−0.86	Mount Weather	8.57	Diamond Springs	1.46
Washington	64.6	−1.2	Trinidad	104	24	Paradise Inn	26	2	0.21	−0.57	Snoqualmie Pass	2.10	35 stations	0.00
West Virginia	75.6	+2.6	Parsons	101	8	Marlinton	44	23	3.58	−1.17	Romney	8.90	Glenville	1.08
Wisconsin	76.0	+6.7	Waupaca	106	12	Prentice	39	31	3.54	−0.36	Park Falls	13.02	Brodhead	0.59
Wyoming	66.1	+1.3	Colony	106	25	South Pass City	18	4	1.40	−0.18	Elk Mountain	4.20	Hyattville	0.00

* For explanation of tables and charts, see this REVIEW, January, 1921, p. 41.

† Other dates also.

TABLE 1.—*Climatological data for Weather Bureau Stations, July, 1921.*

Districts and stations.	Elevation of instruments: Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Pressure: Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Temperature of the air: Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Precipitation: Total.	Departure from normal.	Days with 0.01 inch or more.	Wind: Total movement.	Prevailing direction.	Maximum velocity: Miles per hour.	Direction.	Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet, and ice on ground at end of month.
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F		°F	°F		°F	°F.	°F.	°F.	%	In.	In.		Miles.								0-10	In.	In.
New England.							71.2	+ 2.5										85	4.84	+ 1.2										6.3		
Eastport	76	67	85	29.89	29.97	+0.04	60.1	+ 0.3	87	28	69	48	5	52	30	57	56	90	1.79	− 1.6	7	5,452	s.	36	e.	4	5	16	10	6.0	0.0	0.0
Greenville, Me.	1,070	6	......	......	......	......	70.6		95	8	82	44	17	59	37	......	......	......	5.06	......	10	......	......	......	......	......	16	2	13	......	......	......
Portland, Me.	103	82	117	29.87	29.99	+ .04	69.1	+ 1.1	93	28	77	56	17	61	31	64	62	82	3.20	0.0	13	5,002	s.	30	sw.	28	10	9	12	5.6	0.0	0.0
Concord	288	70	79	29.67	29.97	+ .01	73.6	+ 4.5	95	25	84	53	17	63	34	......	......	......	5.26	+ 1.5	10	2,737	se.	31	w.	28	8	10	13	6.1	0.0	0.0
Burlington	404	11	48	29.53	29.95	+ .01	75.4	+ 7.2	98	8	85	52	17	66	30	......	......	......	2.05	− 1.7	10	6,314	s.	32	s.	27	8	11	12	5.4	0.0	0.0
Northfield	876	12	60	......	29.98	+ .04	71.4	+ 4.8	94	4	84	44	17	59	38	......	......	81	5.98	+ 2.3	10	3,917	s.	25	s.	28	5	12	14	6.5	0.0	0.0
Boston	125	115	188	29.84	29.98	+ .02	73.2	+ 1.9	95	28	80	58	1	66	25	68	66	83	11.69	+ 8.3	10	5,924	sw.	29	w.	28	5	12	14	6.6	0.0	0.0
Nantucket	12	14	90	29.97	29.98	.00	68.6	+ 1.1	81	4	74	54	5	63	20	66	66	95	3.41	+ 0.7	9	10,708	sw.	47	sw.	31	8	8	15	6.6	0.0	0.0
Block Island	26	11	46	29.96	29.99	+ .02	68.6	+ 0.5	83	4	73	58	6	64	17	66	66	93	3.72	+ 0.4	10	10,391	sw.	52	nw.	31	5	6	20	7.5	0.0	0.0
Providence	160	215	251	29.81	29.98	+ .01	73.3	− 0.1	93	4	82	57	1	65	28	68	66	81	5.35	+ 1.8	12	6,513	sw.	36	nw.	31	6	12	13	6.7	0.0	0.0
Hartford	159	122	140	29.81	29.98	+ .01	75.4	+ 3.8	94	4	84	58	22	67	27	69	67	79	4.14	0.0	14	4,656	s.	32	nw.	20	7	8	16	6.9	0.0	0.0
New Haven	106	74	153	29.88	29.90	+ .02	74.6	+ 2.7	95	4	82	58	1	67	25	69	67	81	6.60	+ 1.8	10	5,370	sw.	27	sw.	14	8	12	11	5.5	0.0	0.0
Middle Atlantic States.							77.3	+ 2.7										78	3.60	− 0.7										5.4		
Albany	97	102	115	29.86	29.96	.00	76.5	+ 4.5	96	7	85	58	17	68	27	69	66	75	4.57	+ 0.7	12	4,284	s.	31	sw.	19	17	9	5	4.2	0.0	0.0
Binghamton	871	10	84	29.08	29.98	+ .01	76.0	+ 6.1	96	4	87	55	17	65	31	......	......	......	5.56	+ 2.0	14	2,891	sw.	24	sw.	28	10	9	12	5.4	0.0	0.0
New York	314	414	454	29.66	29.99	+ .01	76.2	+ 2.7	93	4	84	62	1	69	22	69	66	77	3.10	− 1.4	8	9,038	sw.	50	s.	19	6	12	13	6.3	0.0	0.0
Harrisburg	374	94	104	29.61	30.00	+ .02	78.9	+ 4.4	95	3	88	64	23	70	27	69	65	68	1.26	− 2.6	8	3,843	w.	28	sw.	19	10	8	13	5.9	0.0	0.0
Philadelphia	117	123	190	29.88	30.00	+ .02	78.6	+ 2.8	96	4	87	65	1	71	23	73	71	83	4.04	− 0.3	12	5,203	sw.	29	nw.	31	7	9	15	6.6	0.0	0.0
Reading	325	81	98	29.66	30.00	......	78.6	......	97	4	88	63	22	69	29	71	68	74	2.55	− 1.7	9	3,483	se.	27	sw.	19	12	5	14	5.9	0.0	0.0
Scranton	805	111	119	29.16	30.00	+ .02	76.0	+ 4.2	96	4	86	58	16	66	29	68	65	73	4.90	+ 1.1	9	3,599	sw.	30	sw.	27	10	10	11	5.5	0.0	0.0
Atlantic City	52	37	48	29.94	29.99	+ .01	74.2	+ 1.7	93	4	79	63	22	70	19	70	69	86	3.29	− 0.5	9	5,123	sw.	20	w.	20	12	9	10	4.9	0.0	0.0
Cape May	18	13	49	30.00	30.02	+ .04	76.2	+ 2.8	95	4	82	62	23	70	21	71	70	87	3.08	− 0.7	9	5,253	s.	24	nw.	31	12	6	13	5.2	0.0	0.0
Sandy Hook	22	10	55	29.97	29.99	......	75.9	......	92	4	83	62	1	69	22	70	68	83	6.42	......	11	8,463	sw.	52	s.	19	5	16	10	6.0	0.0	0.0
Trenton	190	159	183	29.79	29.98	......	76.8	......	95	4	86	61	22	68	26	70	68	78	2.01	− 2.8	8	6,583	sw.	37	w.	31	10	7	14	6.2	0.0	0.0
Baltimore	123	100	113	29.87	29.99	+ .01	80.2	+ 2.9	96	4	88	66	22	72	23	72	69	72	4.93	+ 0.1	13	4,147	sw.	27	sw.	28	10	9	12	5.4	0.0	0.0
Washington	112	62	85	29.88	29.99	− .01	79.3	+ 2.5	95	28	88	62	23	70	25	72	69	74	4.79	+ 0.1	9	3,539	sw.	26	nw.	28	14	8	9	4.9	0.0	0.0
Lynchburg	681	153	188	29.30	30.02	+ .01	78.8	+ 1.5	98	8	89	58	23	68	29	70	67	74	3.56	− 0.5	10	4,415	w.	34	n.	29	11	19	1	4.2	0.0	0.0
Norfolk	91	170	205	29.93	30.03	+ .03	79.8	+ 1.4	95	8	88	68	23	72	22	73	71	81	3.27	− 2.5	8	8,164	sw.	37	sw.	30	9	13	9	5.6	0.0	0.0
Richmond	144	11	52	29.87	30.01	.00	80.0	+ 0.8	97	8	90	62	23	70	27	72	70	79	2.30	− 2.1	8	5,039	s.	26	n.	15	10	9	12	5.6	0.0	0.0
Wytheville	2,304	49	56	27.73	30.03	+ .02	72.0	− 0.6	88	4	82	51	23	62	28	66	64	81	4.36	− 0.1	20	3,523	w.	23	v.	19	12	17	2	3.9	0.0	0.0
South Atlantic States.							78.8	−0.2										82	8.38	+2.4										6.4		
Asheville	2,255	70	84	27.77	30.05	+ .03	73.2	+ 1.5	89	8	82	60	23	64	26	67	65	82	5.15	+ 0.3	13	4,058	se.	26	e.	22	4	25	2	5.5	0.0	0.0
Charlotte	779	55	62	29.21	30.03	+ .01	79.5	+ 0.8	96	31	89	63	23	70	26	71	69	76	5.55	+ 0.1	12	2,736	sw.	18	s.	2	5	17	9	.7	0.0	0.0
Hatteras	11	12	50	30.03	30.04	+ .03	77.9	− 0.7	89	9	83	67	22	73	14	75	73	87	6.89	+ 0.8	14	9,679	sw.	36	w.	20	8	15	8	5.5	0.0	0.0
Manteo	12	5	42																													
Raleigh	376	103	110	29.64	30.02	.00	78.9	+ 0.4	96	31	88	63	23	70	23	72	70	81	2.67	− 3.4	12	5,136	sw.	31	se.	4	2	18	11	6.8	0.0	0.0
Wilmington	78	81	91	29.97	30.05	+ .04	78.6	− 0.1	94	31	85	67	23	72	21	74	73	85	11.17	+ 4.2	20	5,728	sw.	38	w.	9	4	16	11	6.5	0.0	0.0
Charleston	48	11	92	29.99	30.04	+ .01	80.6	− 0.7	93	1	86	71	14	75	19	75	73	81	16.61	+ 9.4	19	7,532	s.	33	s.	13	3	18	10	6.5	0.0	0.0
Columbia, S. C.	351	41	57	29.67	30.05	+ .03	79.9	− 1.2	96	31	88	68	25	71	23	72	71	82	5.64	− 0.4	16	4,537	s.	34	s.	12	2	15	14	7.0	0.0	0.0
Due West, S. C.	711	10	55	29.31	30.06	......	79.0	......	97	31	88	65	23	70	27	......	......	......	6.10	......	12	4,952	e.	38	sw.	9	1	18	12	7.6	0.0	0.0
Greenville, S. C.	1,039	113	122	28.95	30.02	......	78.6	......	96	31	88	65	23	70	24	70	68	74	3.15	......	10	5,018	e.	27	w.	20	5	20	6	6.7	0.0	0.0
Augusta	180	62	77	29.83	30.02	.00	80.3	− 0.2	97	31	89	69	24	72	24	73	72	81	6.02	+ 0.7	17	3,709	s.	30	e.	3	2	12	17	5.4	0.0	0.0
Savannah	65	150	194	29.97	30.04	+ .01	80.2	− 0.3	95	10	88	69	10	72	26	74	72	84	14.34	+ 8.2	17	7,672	sw.	43	n.	10	2	12	17	7.4	0.0	0.0
Jacksonville	43	209	245	30.00	30.05	+ .02	79.4	− 1.5	92	20	86	68	6	72	19	74	73	86	9.76	+ 3.6	22	8,552	s.	44	nw.	11	5	14	12	7.1	0.0	0.0
Florida Peninsula.							81.4	− 0.9										76	6.67	+ 0.2										6.5		
Key West	22	10	64	30.02	30.04	+ .01	82.2	− 1.5	90	1	87	70	24	77	15	76	73	73	5.72	+ 2.1	12	6,425	se.	30	se.	23	6	16	9	6.1	0.0	0.0
Miami	25	71	79	30.05	30.08	......	81.2	− 0.7	88	29	86	72	29	76	16	75	73	74	3.09	− 4.2	15	5,577	se.	23	se.	23	4	12	15	7.0	0.0	0.0
Sand Key	23	39	72	30.03	30.06	+ .03	81.0	......	89	1	84	72	23	78	11	76	73	74	2.74	......	13	8,360	se.	39	se.	23	7	12	12	5.9	0.0	0.0
Tampa	35	79	92	30.02	30.05	+ .01	80.7	− 0.5	94	9	88	68	23	74	24	74	72	81	11.19	+ 2.8	19	4,073	sw.	28	s.	6	4	18	9	6.9	0.0	0.0
East Gulf States.							81.1	+ 0.9										78	5.47	+ 0.2										5.9		
Atlanta	1,174	190	216	28.84	30.05	+ .03	78.8	+ 1.2	96	31	88	66	13	70	24	71	69	79	3.88	− 0.8	13	6,316	se.	31	se.	7	9	5	17	6.5	0.0	0.0
Macon	370	78	87	29.64	30.03	+ .01	80.2	+ 0.5	98	31	90	68	24	71	27	72	70	79	5.40	+ 0.8	15	3,839	s.	36	nw.	16	2	15	14	6.8	0.0	0.0
Thomasville	273	49	58	29.74	30.03	.00	80.0	− 1.8	95	30	88	69	24	72	23	73	71	83	6.71	+ 1.4	24	2,937	sw.	24	sw.	18	0	11	20	7.9	0.0	0.0
Pensacola	[illegible]	149	185	29.96	30.02	+ .01	80.6	− 0.8	94	31	87	69	12	74	20	75	73	81	6.07	− 1.2	13	8,784	w.	43	ne.	4	4	15	12	6.7	0.0	0.0
Anniston	[illegible]	9	57	29.27	30.05	+ .03	80.6	+ 2.7	98	3	91	66	27	70	29	......	......	......	4.38	− 0.4	13	2,902	s.	26	n.	3	15	15	1	4.1	0.0	0.0
Birmingham	700	11	48	29.29	30.04	+ .03	81.8	+ 0.3	102	4	92	68	23	71	32	72	69	76	5.79	+ 1.1	12	3,585	s.	23	ne.	17	5	21	5	5.4	0.0	0.0
Mobile	57	125	161	29.96	30.02	+ .01	82.2	+ 1.7	98	5	90	69	17	74	24	75	72	78	4.89	− 2.2	18	6,356	sw.	36	ne.	25	3	23	5	5.9	0.0	0.0
Montgomery	223	100	112	29.79	30.03	+ .01	81.7	+ 0.7	98	2	91	66	3	72	29	74	71	77	6.67	+ 2.0	12	3,988	se.	42	w.	13	6	15	10	5.9	0.0	0.0
Corinth	469	6																														
Meridian	375	85	93	29.63	30.01	− .01	81.6	+ 1.6	98	31	92	66	23	71	28	72	69	74	3.76	− 0.7	13	3,550	sw.	32	ne.	4	9	15	7	5.0	0.0	0.0
Vicksburg	247	65	73	29.76	30.03	+ .03	82.0	+ 1.6	97	6	90	66	20	74	22	74	72	80	4.72	+ 0.3	11	3,837	sw.	31	nw.	20	11	12	8	4.9	0.0	0.0
New Orleans	53	76	84	29.97	30.02	+ .02	83.1	+ 1.8	97	5	91	68	22	76	20	75	72	75	7.90	+ 1.4	9	4,067	w.	28	sw.	13	7	15	9	6.0	0.0	0.0
West Gulf States.							82.6	+ 0.4										73	2.19	− 0.9										4.3		
Shreveport	249	77	93	29.74	30.00	+ .02	82.8	+ 0.7	98	6	92	70	10	74	22	74	71	73	4.29	+ 0.6	6	4,308	sw.	26	e.	8	19	7	5	3.5	0.0	0.0
Bentonville	1,303	11	44	......	......	......	79.0	......	99	30	90	60	22	68	27	......	......	......	0.54	......	5	......	......	......	......	......	21	6	4	......	0.0	0.0
Fort Smith	457	79	94	29.51	29.97	.00	82.7	+ 1.7	98	30	93	67	23	73	26	74	70	70	3.15	− 0.7	7	4,210	e.	42	nw.	14	13	14	4	4.1	0.0	0.0
Little Rock	357	136	144	29.62	29.99	.00	82.2	+ 1.6	99	31	91	68	23	73	25	73	70	72	1.44	− 2.6	8	5,030	s.	33	nw.	14	18	9	4	3.7	0.0	0.0
Brownsville	57	4	26																													
Corpus Christi	20	69	77	29.97	29.99	+ .03	82.6	− 0.1	95	7	88	73	15	77	21	76	74	79	0.75	− 0.9	5	8,886	se.	40	n.	8	14	11	6	4.4	0.0	0.0
Dallas	512	109	117	29.43	29.97	......	83.6	......	98	6	93	71	25	74	24	......	......	......	0.63	......	4	6,328	s.	27	ne.	10	14	15	2	3.7	0.0	0.0
Fort Worth	670	106	114	29.25	29.95	− .01	83.4	− 0.3	97	29	93	70	21	74	26	73	68	67	1.14	− 1.9	5	7,448	s.	27	sw.	3	13	13	5	4.0	0.0	0.0
Galveston	54	106	114	29.96	30.02	+ .04	82.2	− 0.8	93	5	86	71	6	78	17	76	74	80	5.77	+ 1.8	11	7,113	se.	32	se.	11	13	11	7	4.7	0.0	0.0
Groesbeck	461	11	56	29.50	29.97	......	82.2	......	96	22	92	69	5	73	24	......	......	......	0.36	......	3	7,373	s.	39	e.	8	12	16	3	4.2	0.0	0.0
Houston	138	111	121	29.85	29.99	......	82.6	− 0.4	94	7	91	72	11	74	21	......	......	......	1.95	......	10	4,850	s.	31	e.	7	4	22	5	5.3	0.0	0.0
Palestine	510	64	72	29.47	29.99	+ .02	82.0	+ 0.5	95	6	90	71	27	74	22	74	72	76	1.27	− 1.7	4	4,921	sw.	24	s.	26	8	16	7	5.3	0.0	0.0
Port Arthur	34	58	66	29.96	30.00	......	81.6	......	95	5	88	70	10	75	21	75	73	80	6.73	......	14	5,722	sw.	30	s.	10	20	6	5	3.5	0.0	0.0
San Antonio	701	119	132	29.25	29.96	+ .01	83.6	+ 1.2	98	22	94	70	26	74	26	72	67	64	0.48	− 1.7	4	5,984	se.	32	e.	6	16	13	2	3.8	0.0	0.0
Taylor	582	55	63	29.41	30.02	+ .06	82.2	− 0.5	97	22	92	68	6	72	27	......	......	......	1.41	− 1.2	8	6,125	s.	56	e.	6	6	22	3	5.2	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau Stations, July, 1921*—Continued.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.									Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Precipitation.			Wind.					Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet, and ice on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.				Total.	Departure from normal.	Days with 0.01 inch or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.						
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F		°F.	°F.	°F.	°F.	%	In.	In.		Miles.								0-10	In.	In.
Ohio Valley and Tennessee.							79.9	+ 3.4										68	3.15	− 0.9										4.3		
Chattanooga	762	189	213	29.24	30.03	+ .01	80.2	+ 2.4	98	31	90	66	23	70	29	71	68	75	4.52	+ 0.6	14	3,989	ne.	36	w.	30	4	24	3	5.5	0.0	0.0
Knoxville	996	102	111	29.00	30.03	+ .01	78.6	+ 2.4	96	5	88	66	1	69	27	70	68	76	7.82	+ 3.6	14	3,690	ne.	50	sw.	15	7	15	9	5.5	0.0	0.0
Memphis	399	76	97	29.62	30.03	+ .03	82.6	+ 1.9	96	31	91	69	6	74	26	74	70	70	3.19	− 0.3	8	4,890	sw.	36	e.	6	19	7	5	3.7	0.0	0.0
Nashville	546	168	191	29.45	30.02	+ .01	82.0	+ 2.6	98	5	92	64	22	72	28	72	68	68	4.56	+ 0.2	10	5,162	w.	57	nw.	31	9	17	5	5.0	0.0	0.0
Lexington	989	193	230	28.98	30.02	+ .01	80.2	+ 3.6	96	6	90	64	21	71	24				1.04	− 3.4	8	7,676	sw.	30	ne.	11	16	10	5	4.1	0.0	0.0
Louisville	525	219	255	29.44	30.02	+ .02	82.5	+ 3.9	98	4	92	64	22	73	26	70	65	61	1.04	− 2.7	5	6,621	n.	33	s.	28	15	12	4	3.9	0.0	0.0
Evansville	431	139	175	29.55	30.00	.00	84.0	+ 4.7	101	4	94	67	21	74	26	71	66	60	2.45	− 1.4	7	5,908	sw.	54	w.	19	7	23	1	4.8	0.0	0.0
Indianapolis	822	194	230	29.14	30.00	+ .01	81.1	+ 4.9	98	14	91	62	21	72	25	69	64	60	1.42	− 2.7	7	6,560	s.	40	sw.	28	14	15	2	4.0	0.0	0.0
Royal Center	736	11	55	29.22	30.00		78.6		99	5	91	52	21	66	35				1.07		6	5,465	n.	26	sw.	27	11	18	2	4.0	0.0	0.0
Terre Haute	575	96	129	29.37	29.97		81.4		98	4	92	61	22	71	20	70	65	61	2.91		7	5,500	n.	54	s.	28	9	20	2	4.4	0.0	0.0
Cincinnati	628	11	51	29.35	30.01	+ .01	79.7	+ 5.7	98	5	91	62	21	69	27		65	64	4.28	+ 0.7	11	3,810	sw.	27	nw.	26	14	15	2	4.1	0.0	0.0
Columbus	824	179	222	29.16	30.01	+ .01	78.7	+ 3.4	96	4	89	60	21	69	25	69	65	66	2.20	− 1.4	9	6,225	sw.	35	w.	19	19	11	1	2.8	0.0	0.0
Dayton	899	181	216	29.04	29.97		80.0	+ 3.8	99	4	90	61	21	69	28	69	64	63	1.34	− 1.9	8	5,871	sw.	48	ne.	11	18	13	0	3.1	0.0	0.0
Elkins	1,947	59	67	28.05	30.03	+ .02	72.6	+ 2.1	89	8	84	52	23	61	33	66	64	85	4.69	0.0	17	2,362	s.	24	sw.	19	6	20	5	5.3	0.0	0.0
Parkersburg	638	77	84	29.38	30.03	+ .02	78.6	+ 3.0	95	8	89	63	23	68	27	70	67	73	2.80	− 1.9	8	2,895	se.	26	nw.	8	18	8	5	4.0	0.0	0.0
Pittsburgh	842	353	410	29.13	30.01	+ .01	77.6	+ 3.0	94	5	87	62	31	68	25	69	66	68	2.81	− 1.6	7	5,518	sw.	36	nw.	8	12	15	4	4.4	0.0	0.0
Lower Lake Region.							77.6	+5.9										66	2.92	−0.6										4.1		
Buffalo	767	247	280	29.17	29.98	+ .01	76.2	+6.0	88	11	82	57	31	70	21	68	65	70	1.42	−2.0	5	8,890	sw.	44	sw.	28	16	10	5	4.1	0.0	0.0
Canton	448	10	61	29.47	29.93		76.4	+5.9	99	7	88	48	16	65	32				2.20	−1.0	10	5,934	sw.	42	sw.	18	15	12	4	3.8	0.0	0.0
Oswego	335	76	91	29.60	29.96	.00	75.8	+6.2	94	7	83	61	17	68	23	69	66	73	2.04	−1.2	9	4,919	s.	26	ne.	15	11	13	7	4.7	0.0	0.0
Rochester	523	86	102	29.43	29.98	+ .01	77.8	+7.4	97	8	87	58	31	69	24	68	64	65	3.95	+0.9	10	4,572	sw.	28	nw.	8	15	10	6	4.4	0.0	0.0
Syracuse	597	97	113	29.36	29.99	+ .02	76.6	+5.8	97	7	86	57	31	68	25				4.44	−0.8	11	5,272	s.	34	nw.	31	4	15	12	6.3	0.0	0.0
Erie	714	130	166	29.24	29.98	.00	77.6	+5.8	93	6	85	62	22	70	22	70	66	68	3.05	−0.2	8	6,955	nw.	36	s.	27	15	12	4	3.9	0.0	0.0
Cleveland	762	190	201	29.20	30.00	+ .01	76.8	+4.3	95	6	84	62	22	69	23	69	65	67	3.52	0.0	9	6,931	s.	46	nw.	14	16	14	1	3.5	0.0	0.0
Sandusky	629	62	103	29.33	30.00	+ .01	78.7	+5.1	98	18	87	62	31	70	26				3.26	−0.5	13	6,692	sw.	42	w.	30	12	17	2	3.7	0.0	0.0
Toledo	628	208	243	29.33	30.00	+ .01	79.0	+5.3	96	18	88	60	21	70	25	69	64	65	2.86	−0.4	10	8,019	sw.	56	nw.	29	19	11	1	3.2	0.0	0.0
Fort Wayne	856	113	124	29.10	30.00		79.6	+6.1	98	4	90	59	21	69	28	68	62	50	1.00		5	5,095	sw.	31	sw.	27	9	20	2	4.3	0.0	0.0
Detroit	730	218	245	29.23	30.00	+ .02	79.0	+7.0	96	5	88	61	31	70	22	68	64	64	2.49	−1.0	7	6,210	sw.	56	sw.	27	20	10	1	3.2	0.0	0.0
Upper Lake Region.							75.6	+7.6										69	2.73	−0.4										4.1		
Alpena	609	13	92	29.33	29.99	+.02	73.7	+7.9	91	30	83	54	31	65	33	68	64	72	4.30	+1.2	12	6,048	se.	56	s.	13	10	17	4	4.2	0.0	0.0
Escanaba	612	54	60	29.31	29.96	−.01	73.8	+7.3	92	13	82	49	31	66	28	67	64	73	1.91	−1.4	13	5,993	s.	42	ne.	24	19	9	3	3.6	0.0	0.0
Grand Haven	632	54	89	29.31	29.98	.00	75.0	+5.3	94	5	84	53	21	66	26	68	63	66	0.92	−1.7	6	6,639	s.	36	nw.	7	15	12	4	3.5	0.0	0.0
Grand Rapids	707	70	87	29.24	29.98	.00	79.8	+7.2	100	5	91	58	31	68	30	68	63	58	2.38	−0.2	6	3,311	w.	21	ne.	6	12	14	5	4.7	0.0	0.0
Houghton	684	62	99	29.24	29.95	−.01	72.6	+7.3	95	10	82	50	31	63	27				4.09	+1.0	8	5,911	e.	43	ne.	1	8	12	11	5.7	0.0	0.0
Lansing	878	11	62	29.07	29.98		77.0	+5.9	97	4	89	53	21	65	32	68	64	69	2.61	+0.6	9	2,711	sw.	32	nw.	14	11	18	2	4.0	0.0	0.0
Ludington	637	60	66	29.30	29.98		73.4		93	5	81	53	21	66	23	67	63	67	2.96		7	6,416	s.	34	nw.	7	20	9	2	2.7	0.0	0.0
Marquette	734	77	111	29.20	29.98	+.02	72.3	+7.4	95	10	81	53	31	64	28	66	64	77	4.39	+1.3	13	6,153	s.	41	sw.	7	6	15	10	5.5	0.0	0.0
Port Huron	638	70	120	29.30	29.99	+.01	76.7	+7.7	97	4	85	58	31	68	27	70	68	76	2.28	−0.5	11	6,086	sw.	38	sw.	27	16	14	1	3.2	0.0	0.0
Saginaw	641	69	77	29.31	29.99		77.5		98	5	88	55	31	66	29	69	65	69	1.10	−2.6	7	4,583	s.	36	sw.	18	13	15	3	4.2	0.0	0.0
Sault Sainte Marie	614	11	52	29.29	29.97	.00	74.1	+12.2	98	3	85	52	31	63	31	67	64	76	3.10	+0.4	10	4,237	nw.	36	n.	13	14	10	7	4.4	0.0	0.0
Chicago	823	140	310	29.13	29.99	+.01	81.2	+8.8	97	17	88	67	31	74	24	70	64	60	1.87	−1.8	3	7,112	sw.	40	w.	7	17	13	1	3.3	0.0	0.0
Green Bay	617	109	144	29.31	29.95	−.02	77.4	+7.9	99	11	88	54	31	67	30	68	63	64	2.48	−1.0	10	6,732	s.	42	w.	2	11	13	7	5.2	0.0	0.0
Milwaukee	681	125	139	29.26	29.98	+.01	78.6	+8.9	96	17	86	59	31	71	26	68	63	61	1.35	−1.7	5	6,571	sw.	28	sw.	27	13	13	5	4.1	0.0	0.0
Duluth	1,133	11	47	28.76	29.95	.00	70.8	+4.8	94	10	80	50	30	61	27	65	62	75	5.41	+1.8	11	7,067	ne.	36	nw.	31	13	14	4	3.9	0.0	0.0
North Dakota.							71.6	+2.6										64	3.02	+0.1										4.1		
Moorhead	940	50	58	28.98	29.94	.00	72.8	+ 4.1	96	1	84	50	31	61	34	64	59	66	3.08	− 0.7	8	5,780	s.	37	nw.	26	12	12	7	4.8	0.0	0.0
Bismarck	1,674	8	57	28.21	29.95	+ .02	74.2	+ 4.0	108	9	87	49	31	61	37	62	54	57	2.18	0.0	9	6,627	e.	42	n.	12	11	18	2	4.0	0.0	0.0
Devils Lake	1,482	11	44	28.38	29.92	− .01	70.0	+ 1.9	97	9	81	51	6	50	34	63	58	70	4.49	+ 0.7	12	6,085	se.	34	w.	1	16	9	6	4.1	0.0	0.0
Ellendale	1,457	10	56	28.42	29.95		71.0		95	1	83	50	31	50	37				5.84		9	8,514	s.	84	w.	2	15	11	5	4.2	0.0	0.0
Grand Forks	835	12	89				71.8		99	1	84	52	31	60	41				4.08		9		n.	38	nw.	27	13	15	3		0.0	0.0
Williston	1,878	41	48	27.97	29.91	− .01	69.6	+ 0.2	96	8	82	47	31	58	38	60	55	65	2.35	+ 0.3	9	5,798	se.	42	e.	25	15	15	1	3.5	0.0	0.0
Upper Mississippi Valley.							79.9	+ 4.5										64	2.17	− 1.5										3.8		
Minneapolis	918	102	208	28.98	29.94		77.4		98	11	87	55	31	68	26				3.16	− 0.6	10	7,005	sw.	42	n.	13	12	14	5	4.4	0.0	0.0
St. Paul	837	236	261	29.07	29.96	+ .01	76.7	+ 4.6	96	10	87	55	31	67	28				2.39	− 1.0	11	7,338	sw.	44	s.	26	15	15	1	3.2	0.0	0.0
La Crosse	714	11	48	29.21	29.96	.00	77.5	+ 4.9	98	11	89	55	31	66	30				2.36	− 1.7	10	2,813	s.	22	s.	4	16	11	4	3.8	0.0	0.0
Madison	974	70	78	28.98	29.99	+ .02	78.1	+ 5.7	98	12	88	60	31	68	28	68	64	66	2.46	− 1.5	6	4,787	sw.	25	sw.	26	10	16	5	4.7	0.0	0.0
Wausau	1,247	4		28.67	29.97		75.0		101	11	87	51	31	63	37				2.41		12		s.				9	17	5	5.3	0.0	0.0
Charles City	1,015	10	49	28.93	29.98	+ .02	77.4	+ 3.9	96	10	89	53	31	66	30	69	65	66	1.83	− 1.8	9	3,815	sw.	24	nw.	24	14	16	1	3.5	0.0	0.0
Davenport	606	71	79	29.34	29.99	+ .02	80.9	+ 5.5	101	12	91	61	31	71	27	70	65	62	2.21	− 1.3	5	4,005	sw.	27	sw.	4	17	10	4	3.8	0.0	0.0
Des Moines	861	84	97	29.08	29.96	.00	79.6	+ 4.1	96	10	89	59	31	70	25	70	65	66	2.49	− 1.4	8	3,991	sw.	28	sw.	27	18	9	4	3.7	0.0	0.0
Dubuque	698	81	96	29.27	30.00	+ .03	79.0	+ 4.3	98	11	89	59	21	69	29	69	65	66	2.48	− 1.8	9	3,487	sw.	34	nw.	12	12	15	4	4.1	0.0	0.0
Keokuk	614	64	78	29.34	30.00	+ .02	81.8	+ 4.8	99	13	92	65	22	72	27	70	65	59	0.55	− 3.5	6	3,906	s.	29	sw.	4	10	15	6	4.5	0.0	0.0
Cairo	356	87	93	29.61	29.98	− .02	83.0	+ 4.4	97	14	92	67	31	74	30	73	69	67	0.98	− 2.5	8	4,774	s.	60	nw.	31	15	10	6	4.3	0.0	0.0
Peoria	609	11	45	29.35	30.01	+ .03	79.8	+ 4.4	101	13	92	57	21	68	31	70	66	65	3.95	+ 1.0	6	2,962	ne.	38	nw.	14	22	9	0	2.1	0.0	0.0
Springfield, Ill	644	10	91	29.32	29.98	.00	81.2	+ 4.7	100	13	92	61	21	70	28	70	66	64	1.67	− 1.2	6	4,296	s.	33	w.	4	17	12	2	3.4	0.0	0.0
Hannibal	534	74	109	29.43	29.99	+ .01	80.7	+ 3.3	98	12	91	56	22	70	34				1.78	− 2.0	6	4,683	sw.	38	sw.	4	17	9	5	3.8	0.0	0.0
St. Louis	567	265	303	29.40	29.99	.00	83.2	+ 4.1	98	13	92	65	31	74	26	70	64	56	2.05	− 1.4	7	6,673	s.	42	sw.	14	19	12	0	2.6	0.0	0.0
Missouri Valley.							78.4	+ 2.7										68	3.36	− 0.5										3.8		
Columbia, Mo	781	11	84	29.18	29.98	.00	79.8	+ 2.4	98	27	1	61	2	69	30				2.69	− 1.0	5	3,983	s.	36	sw.	4	18	10	3	3.3	0.0	0.0
Kansas City	963	161	181	28.98	29.98	+ .01	81.1	+ 3.5	96	30	90	62	21	72	22	71	67	65	1.87	− 3.0	6	5,661	s.	43	n.	31	18	10	3	3.4	0.0	0.0
St. Joseph	967	11	49	28.96	29.96		80.6		99	30	91	61	31	70	26	71	67	68	2.66		8	4,396	se.	30	nw.	31	20	10	1	2.9	0.0	0.0
Springfield, Mo	1,324	98	104	28.64	30.01	+ .03	79.2	+ 2.8	94	30	98	66	31	71	22	71	67	70	0.70	− 4.1	3	5,656	se.	24	se.	10	25	5	1	2.2	0.0	0.0
Iola	984	11	50	28.96	29.97	.00	80.8	+ 2.7	97	30	82	61	22	70	28				4.03	+ 0.1	5	3,593	s.	24	w.	28	15	12	4	4.2	0.0	0.0
Topeka	987	92	107				79.8	+ 2.2	99	27	90	63	22	70	26				4.09	− 0.8	7	5,704	s.	36	nw.	18	10	15	6	4.5	0.0	0.0
Drexel	1,299	10	53	28.61	29.96		76.7		95	1	97	59	21	67	26	70	67	76	7.57		14	5,716	s.	30	sw.	5	14	9	8	4.4	0.0	0.0
Lincoln	1,189	11	84	28.72	29.95	.00	78.8	+ 2.4	96	10	89	61	33	68	28	70	66	71	4.75	+ 0.9	11	6,005	s.	36	sw.	5	11	10	10	4.8	0.0	0.0
Omaha	1,105	115	122	28.83	29.97	+ .02	79.6	+ 3.1	97	9	88	62	1	71	24	71	68	71	4.99	+ 0.7	14	4,314	se.	38	n.	13	15	10	6	4.0	0.0	0.0
Valentine	2,598	47	54	27.30	29.96	+ .03	75.2	+ 2.0	98	21	87	53	37	63	36	63	57	60	3.42	0.0	10	7,066	s.	40	nw.	2	13	14	4	3.8	0.0	0.0
Sioux City	1,135	94	164	28.78	29.96	+ .01	77.6	+ 3.4	96	9	87	58	3	68	29	69	64	68	2.06	− 1.6	9	7,318	s.	50	nw.	13	11	14	6	4.6	0.0	0.0
Huron	1,306	59	74	28.59	29.96	+ .02	74.8	+ 3.3	97	16	86	50	4	63	37	66	62	69	4.17	+ 1.2	9	5,879	se.	42	w.	2	16	10	5	3.5	0.0	0.0
Pierre	1,572	70	75	28.30	29.92	− .01	77.3	+ 2.1	102	1	89	55	1	65	36	66	60	61	4.92	+ 2.6	8	6,367	se.	64	nw.	2	15	12	4	3.7	0.0	0.0
Yankton	1,233	49	57	28.66	29.94	.00	77.4	+ 2.8	98	10	88	52	33	67	32				2.63	− 0.9	10	4,607	w.	32	nw.	13	10	17	4	4.6	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau Stations, July, 1921*—Continued.

Districts and stations.	Elevation of instruments: Barometer above sea level.	Elevation of instruments: Thermometer above ground.	Elevation of instruments: Anemometer above ground.	Pressure: Station, reduced to mean of 24 hours.	Pressure: Sea level, reduced to mean of 24 hours.	Pressure: Departure from normal.	Temperature of the air: Mean max.+mean min.÷2.	Temperature of the air: Departure from normal.	Temperature of the air: Maximum.	Temperature of the air: Date.	Temperature of the air: Mean maximum.	Temperature of the air: Minimum.	Temperature of the air: Date.	Temperature of the air: Mean minimum.	Temperature of the air: Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Precipitation: Total.	Precipitation: Departure from normal.	Precipitation: Days with 0.01 inch or more.	Wind: Total movement.	Wind: Prevailing direction.	Wind: Maximum velocity: Miles per hour.	Wind: Maximum velocity: Direction.	Wind: Maximum velocity: Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet, and ice on ground at end of month.
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F		°F	°F		°F	°F.	°F.	°F	%	In.	In.		Miles								0-10	In.	In.
Northern Slope.							**68.9**	**+ 1.4**										**52**	**1.07**	**− 0.6**										**3.4**		
Billings	3,140	5																														
Havre	2,505	11	44	27.35	29.93	+ .02	69.8	+ 1.7	102	20	84	47	30	55	43	58	51	60	2.51	+ 0.6	10	4,819	e.	25	e.	14	22	7	2	2.9	0.0	0.0
Helena	4,110	87	112	25.83	29.93	.00	69.2	+ 2.6	98	20	83	41	4	55	40	52	40	41	0.29	− 0.8	7	6,661	sw.	37	s.	14	19	7	5	3.4	0.0	0.0
Kalispell	2,973	48	56	26.93	29.92	− .01	65.0	+ 0.7	96	19	80	44	6	51	42	51	39	47	0.62	− 0.2	6	4,381	nw.	24	w.	20	23	4	4	2.9	0 0	0.0
Miles City	2,371	26	48																													
Rapid City	3,259	50	58	26.64	29.97	+ .04	72.8	+ 2.6	99	9	86	47	4	60	37	59	51	51	1.65	− 0.9	11	5,114	w.	38	nw.	27	12	16	3	4.4	0.0	0.0
Cheyenne	6,088	84	101	24.13	29.96	+ .04	66.8	− 0.6	89	1	80	43	3	54	36	54	47	56	1.37	− 0.6	10	7,358	s.	48	s.	14	15	13	3	4.0	0.0	0.0
Lander	5,372	60	68	24.72	29.94	+ .02	68.8	+ 0.8	96	20	85	32	3	53	45	53	43	45	0.38	− 0.5	5	3,913	w.	40	w.	14	14	16	1	4.0	0.0	0.0
Sheridan	3,790	10	47	26.13	29.95		69.9		99	8	86	36	3	53	48	56	47	51	0.56		7	3,919	nw.	29	s.	10	26	3	2	1.4	0.0	0.0
Yellowstone Park	6,200	11	48	23.98	29.97	+ .05	62.1	+ 0.6	88	20	77	32	2	47	39	49	40	52	0.93	− 0.2	8	4,768	sw.	42	s.	20	12	15	4	4.6	3.8	0.0
North Platte	2,821	11	51	27.12	29.98	+ .05	76.8	+ 2.9	97	2	90	53	4	64	34	65	60	65	0.80	− 1.9	6	4,935	e.	23	n.	2	19	8	4	3.0	0.0	0.0
Middle Slope.							**77.6**	**+ 0.8**										**63**	**3.30**	**+ 0.3**										**4.3**		
Denver	5,292	106	113	24.82	29.96	+ 0.5	72.4	+ 0.6	97	2	84	49	5	61	39	58	49	51	1.27	− 0.4	6	5,449	s.	42	nw.	21	17	10	4	3.7	0.0	0.0
Pueblo	4,685	80	86	25.36	29.93	+ 0.2	74.2	0.0	99	2	87	50	6	61	39	60	53	58	5.26	+ 3.3	8	3,906	e.	26	nw.	17	12	15	4	4.6	0.0	0.0
Concordia	1,392	50	58	28.54	29.98	+ 0.3	79.2	+ 1.1	95	13	90	62	3	69	27	69	65	68	5.24	+ 1.6	9	4,805	s.	26	s.	2	13	11	7	4.7	0.0	0.0
Dodge City	2,509	11	51	27.44	29.98	+ .05	78.4	+ 0.7	98	30	89	63	7	68	29	68	63	66	2.91	− 0.5	8	7,161	se.	34	se.	2	17	10	4	3.8	0.0	0.0
Wichita	1,358	139	158	28.56	29.95	− .01	81.0	+ 2.0	102	30	90	66	22	72	30	70	65	63	0.71	− 2.9	4	8,466	s.	39	e.	30	15	13	3	3.9	0.0	0.0
Altus	1,410	5					83.9		104	14	97	66	10	71	34				0.53		1		se.				16	5	10		0.0	0.0
Broken Arrow	765	11	52	29.17	29.99		80.3		98	30	89	64	21	71	23				0.63		3	7,310	s.	30	s.	2	11	16	4	4.8	0.0	0.0
Muskogee	652	4					83.2		101	30	94	65	23	72	29				0.39		4		se.				15	14	2		0.0	0.0
Oklahoma City	1,214	10	47	28.72	29.96	− .00	80.3	+ 0.6	96	8	90	65	21	71	25	72	69	72	4.43	+ 0.8	6	7,543	s.	40	s.	3	14	10	7	4.4	0.0	0.0
Southern Slope.							**79.6**	**− 0.8**										**47**	**2.13**	**− 0.7**										**4.2**		
Abilene	1,738	10	52	28.17	29.93	.00	83.0	+ 0.8	100	23	94	66	10	72	28	69	62	56	0.44	− 2.0	2	6,790	s.	39	sw.	3	12	13	6	4.5	0.0	0.0
Amarillo	3,676	10	49	26.33	29.98	+ .06	74.8	− 1.3	94	2	85	61	11	65	28	66	62	71	4.17	+ 1.0	12	6,733	s.	26	s.	2	14	15	2	4.4	0.0	0.0
Del Rio	944	64	71	28.97	29.93	+ .03	84.4	− 0.3	98	10	95	69	11	74	26				1.73	− 0.5	6	8,019	se.	34	e.	11	20	9	2	3.3	0.0	0.0
Roswell	3,566	75	85	26.39	29.92	+ .04	76.3	− 2.6	103	2	87	59	7	65	36	64	58	61	2.18	− 1.3	10	4,605	s.	28	sw.	28	15	8	8	4.8	0.0	0.0
Southern Plateau.							**78.7**	**− 0.3**										**47**	**1.30**	**+ 0.1**										**3.8**		
El Paso	3,762	110	133	26.19	29.84	.00	79.8	− 0.7	100	2	90	63	6	70	28	65	57	51	2.13	0.0	9	7,930	e.	42	sw.	3	12	15	4	4.5	0.0	0.0
Santa Fe	7,013	57	66	23.38	29.90	+ .02	67.1	− 1.6	88	1	78	46	5	56	28	56	51	64	3.87	+ 1.2	16	4,787	se.	30	ne.	10	7	17	7	5.5	0.0	0.0
Flagstaff	6,908	10	59	23.47	29.88	+ .05	64.9	− 0.1	87	1	78	36	5	52	42	51			3.78		12		w.	34	sw.	2	8	17	6		0.0	0.0
Phoenix	1,108	76	81	28.68	29.79	+ .01	89.2	− 1.2	110	22	101	64	5	77	42	70	61	45	0.38	− 0.7	7	4,634	e.	36	ne.	25	10	15	6	4.4	0.0	0.0
Yuma	141	9	54	29.64	29.77	+ .01	91.3	+ 0.4	111	22	104	64	5	78	42	73	65	49	0.05	− 0.1	1	4,635	s.	31	s.	13	22	8	1	2.3	0.0	0.0
Independence	3,957	9	41	25.96	29.89	+ .06	79.9	+ 1.4	100	23	95	54	4	65	37	57	40	28	0.06	− 0.1	3	4,260	s.	22	w.	1	22	7	2	2.2	0.0	0.0
Middle Plateau.							**73.9**	**+ 1.1**										**36**	**0.73**	**+ 0.2**										**2.7**		
Reno	4,532	74	81	25.50	29.91	+ .04	71.7	+ 4.2	96	19	90	37	3	54	45	51	36	35	0.15	0.0	3	5,297	w.	35	w.	24	27	4	0	1.0	0.0	0.0
Tonopah	6,090	12	20	24.13	29.90		75.5		95	23	88	45	3	63	30	53	34	25	0.01	− 0.3	1	4,873	se.	33	nw.	2	19	12	0	2.4	0.0	0.0
Winnemucca	4,344	18	56	25.63	29.93	+ .03	72.0	+ 0.4	96	15	91	37	3	53	46	51	34	31	T.	− 0.2	0	4,489	sw.	36	nw.	2	27	3	1	1.4	0.0	0.0
Modena	5,479	10	43	24.66	29.88	+ .02	71.9	+ 2.0	95	7	88	40	3	56	45	54	40	40	2.50	+ 1.2	10	7,510	w.	40	w.	2	17	12	2	3.2	T.	0.0
Salt Lake City	4,360	163	203	25.63	29.90	.00	77.4	+ 1.2	99	8	89	46	3	65	34	58	44	35	0.36	− 0.2	3	5,618	se.	44	sw.	7	16	14	1	3.2	0.0	0.0
Grand Junction	4,602	60	68	25.42	29.92	+ .03	76.7	− 2.5	98	20	90	47	5	63	34	60	50	47	1.38	+ 0.9	7	4,706	se.	39	se.	26	12	13	6	4.8	0.0	0.0
Northern Plateau.							**71.6**	**+ 0.7**										**39**	**0.29**	**− 0.2**										**2.1**		
Baker	3,471	48	53	26.48	30.01	+ .06	65.0	0.0	93	19	82	34	3	48	44	51	40	45	0.08	− 0.4	1	4,616	nw.	22	nw.	1	25	4	2	1.5	0.0	0.0
Boise	2,739	78	86	27.13	29.92	− .01	74.1	+ 1.3	103	19	90	40	3	58	40	56	41	36	T.	− 0.2	0	3,935	w.	25	se.	31	25	6	0	1.5	0.0	0.0
Lewiston	757	40	48	29.17	29.97	+ .02	74.0	+ 0.4	102	18	91	46	3	57	45				0.22	− 0.2	3	2,753	e.	31	nw.	1	24	2	5	1.9	0.0	0.0
Pocatello	4,477	60	68	25.50	29.91	− .01	73.0	+ 1.8	98	20	88	36	3	58	37	54	41	39	1.06	+ 0.4	6	6,111	se.	40	sw.	23	16	9	6	4.1	T.	0.0
Spokane	1,929	101	110	27.95	29.96	.00	69.8	+ 1.0	94	24	85	46	3	55	38	54	40	41	0.02	− 0.6	1	4,911	sw.	29	sw.	20	25	3	3	2.0	0.0	0.0
Walla Walla	991	57	65	28.93	29.98	+ .01	73.8	− 0.3	98	7	88	46	2	60	37	55	39	33	0.38	0.0	4	3,655	s.	36	w.	1	25	2	4	1.7	0.0	0.0
North Pacific Coast Region.							**60.6**	**− 1.4**										**74**	**0.13**	**− 0.6**										**4.4**		
North Head	211	11	56	29.95	30.18	+ .10	55.5	− 2.2	62	7	58	50	23	53	10	53	52	87	0.13	− 0.4	7	13,490	n.	50	n.	9	5	18	8	5.4	0.0	0.0
Port Angeles	29	8	53	30.15	30.18		56.0		69	22	64	42	9	48	24				0.03	− 0.4	1	6,735	nw.	31	w.	1	16	12	3	3.4	0.0	0.0
Seattle	125	215	250	30.02	30.15	+ .11	60.8	− 2.7	77	22	69	47	2	52	24	54	49	70	0.18	− 0.5	1	4,789	w.	25	n.	9	11	14	6	4.7	0.0	0.0
Tacoma	213	113	120	29.93	30.15	+ .10	61.4	− 2.0	79	23	71	47	2	52	27				0.01	− 0.6	1	4,262	n.	23	sw.	1	7	21	3	5.0	0.0	0.0
Tatoosh Island	86	7	57	30.07	30.17	+ .12	53.5	− 1.6	60	6	56	49	6	50	11	52	51	92	0.22	− 1.6	9	7,529	w.	35	w.	1	4	9	18	7.2	0.0	0.0
Yakima	1,071	4					71.0		98	31	88	42	3	54	42				T.		0		nw.				24	6	1			
Medford	1,425	4																														
Portland, Oreg.	153	68	106	29.96	30.12	+ .07	65.7	− 0.6	89	7	77	46	3	55	30	57	50	62	T.	− 0.5	0	4,969	nw.	23	w.	1	14	13	4	3.8	0.0	0.0
Roseburg	510	9	57	29.54	30.08	+ .05	66.9	+ 0.8	93	22	83	41	2	50	41	56	47	58	0.32	− 0.3	0	3,145	n.	14	n.	8	26	5	0	1.2	0.0	0.0
Middle Pacific Coast Region.							**64.9**	**+ 0.8**										**62**	**0.00**	**0.0**										**3.1**		
Eureka	62	73	89	30.02	30.09	+ .04	53.8	− 1.5	62	7	58	46	4	50	13	51	48	85	0.00	− 0.1	0	5,343	nw.	39	n.	2	7	15	9	5.7	0.0	0.0
Point Reyes Light	490	7	18	29.40	29.92		53.4	− 0.3	75	7	58	46	30	49	24				0.00	0.0	0	16,443	nw.	49	nw.	1	8	3	20	6.8	0.0	0.0
Red Bluff	332	50	56	29.51	29.85	− .04	82.4	+ 0.3	106	7	99	59	31	66	38	61	44	32	0.00	0.0	0	3,923	se.	40	nw.	2	31	0		0.0	0.0	0.0
Sacramento	69	106	117	29.79	29.86	− .02	75.3	+ 2.8	106	7	93	50	18	58	47	61	51	42	0.00	0.0	0	6,589	s.	38	nw.	2	31	0		0.2	0.0	0.0
San Francisco	155	208	243	29.77	29.94	− .01	59.8	+ 2.5	94	6	67	50	24	53	33	54	50	78	0.00	0.0	0	6,767	sw.	30	sw.	9	15	11	5	4.3	0.0	0.0
San Jose	141	12	110	29.81	29.96		67.4		102	6	82	47	26	53	45				0.00		0	4,770	nw.	23	nw.	3	26	5	0	1.7	0.0	0.0
South Pacific Coast Region.							**72.4**	**+ 1.8**										**64**	**T.**	**0.0**										**2.5**		
Fresno	327	89	98	29.50	29.84	+ .01	83.9	+1.9	110	7	101	60	31	67	39	60	42	29	0.00	0.0	0	6,101	nw.	25	nw.	2	27	3	1	0.8	0.0	0.0
Los Angeles	338	159	191	29.56	29.92	+ .02	71.8	+1.4	86	21	81	59	7	62	23	63	60	74	T.	0.0	0	3,707	sw.	15	sw.	30	25	6	0	2.3	0.0	0.0
San Diego	87	62	70	29.82	29.91	− .01	68.4	+1.5	77	22	73	59	1	64	11	64	62	82	T.	0.0	0	4,342	sw.	20	nw.	5	13	16	2	4.3	0.0	0.0
San Luis Obispo	201	32	40	29.73	29.95	.00	65.5	+2.3	93	6	78	46	26	53	44	56	52	72	T.	0.0	0	2,618	nw.	12	nw.	29	24	6	1	2.6	0.0	0.0
West Indies.																																
San Juan, P. R.	82	8	54	29.97	30.06		78.7		90	9	83	71	29	74	17				8.43	+2.0	24	10,079	e.	38	e.	10	5	16	10	6.2	0.0	0.0
Panama Canal.																																
Balboa Heights	118	7	97	29.72	29.85	+ .01	80.5	+0.2	91	22	87	70	8	74	18	75	74	87	8.07	+0.4	14	4,714	nw.	34	n.	10	0	16	15	7.5	0.0	0.0
Colon	36	7	97	29.82	29.85	.00	80.8	+0.8	89	22	80	72	7	76	16	76	75	86	10.49	−5.4	26	6,192	n.	25	se.	7	0	5	26	8.8	0.0	0.0
Alaska.																																
Juneau	80	11	49				54.0		73	18	59	44	31	49	28	52	50	88	7.09		22	2,339	s.	13	se.	16	1	1	29	9.4	0.0	0.0

TABLE 2.—*Data furnished by the Canadian Meteorological Service, July, 1921.*

Stations.	Altitude above mean sea level, Jan. 1, 1919.	Pressure.			Temperature of the air.						Precipitation.		
		Station reduced to mean of 24 hours.	Sea level reduced to mean of 24 hours.	Departure from normal.	Mean max. + mean min. ÷2.	Departure from normal.	Mean maximum.	Mean minimum.	Highest.	Lowest.	Total.	Departure from normal.	Total snowfall.
	Feet.	*Inches.*	*Inches.*	*Inches.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	*Inches.*	*Inches.*	*Inches.*
St. Johns, N. F.	125												
Sydney, C. B. I.	48												
Halifax, N. S.	88	29.88	29.98	+0.02	66.3	+ 2.9	74.5	58.1	84	46	1.41	−2.64	0.0
Yarmouth, N. S.	65	29.91	29.98	+ .03	62.3	+ 2.8	69.4	55.3	82	47	2.91	−0.71	0.0
Charlottetown, P. E. I.	38	29.91	29.95	+ .05	68.6	+ 4.5	78.1	59.1	88	49	0.76	−2.73	0.0
Chatham, N. B.	28	29.92	29.94	+ .06	71.6	+ 6.6	83.7	59.5	95	46	3.32	−0.87	0.0
Father Point, Que.	20												
Quebec, Que.	296	29.63	29.95	+ .04	72.5	+ 7.0	81.9	63.2	96	51	4.54	+0.28	0.0
Montreal, Que.	187	29.72	29.92	− .01	76.2	+ 7.7	85.7	66.8	95	55	2.21	−2.08	0.0
Stonecliffe, Ont.	489	29.35	29.95	+ .01	73.6	+ 8.0	88.2	59.1	104	46	3.09	−0.03	0.0
Ottawa, Ont.	236	29.69	30.02	+ .08	76.1	+ 6.6	87.6	64.6	98	54	2.38	−1.09	0.0
Kingston, Ont.	285	29.64	29.93	− .04	76.5	+ 8.3	83.4	69.7	89	61	2.30	−0.59	0.0
Toronto, Ont.	379	29.57	29.93	− .04	77.8	+ 9.8	88.1	67.6	98	59	2.65	−0.27	0.0
Cochrane, Ont.	930												
White River, Ont.	1,244	28.64	29.91	− .03	68.1	+ 8.6	84.2	51.9	96	36	5.35	+2.55	0.0
Port Stanley, Ont.	592												
Southampton, Ont.	656	29.28			73.0	+ 8.3	82.0	63.1	91	52	3.59	+2.61	0.0
Parry Sound, Ont.	688	29.29	29.96	.00	76.7	+10.7	89.4	64.0	100	53	2.40	−0.22	0.0
Port Arthur, Ont.	644	29.26	29.95	+ .01	70.3	+ 8.3	80.7	60.0	92	42	4.43	+0.95	0.0
Winnipeg, Man.	760	29.09	29.90	− .03	70.5	+ 4.5	81.9	59.0	94	49	3.71	+0.63	0.0
Minnedosa, Man.	1,690	28.14	29.91	− .02	67.9	+ 5.7	81.1	54.8	91	45	1.06	−1.54	0.0
Le Pas, Man.	860												
Qu'Appelle, Sask.	2,115	27.69	29.89	− .03	66.2	+ 2.7	79.3	53.2	90	43	3.71	+1.23	0.0
Medicine Hat, Alb.	2,144												
Moose Jaw, Sask.	1,759												
Swift Current, Sask.	2,392	27.40	29.91	.00	67.1	+ 0.6	81.7	52.5	99	43	2.46	+0.02	0.0
Calgary, Alb.	3,428												
Banff, Alb.	4,521												
Edmonton, Alb.	2,150	27.63	29.88	− .02	61.4	+ 0.8	74.2	48.6	87	40	3.65	+0.62	0.0
Prince Albert, Sask.	1,450	28.35	29.88	− .03	65.1	+ 3.2	77.3	53.0	86	46	3.20	+1.15	0.0
Battleford, Sask.	1,592	28.17	29.88	− .02	65.7	+ 1.0	79.2	52.2	94	46	2.89	+0.55	0.0
Kamloops, B. C.	1,262												0.0
Victoria, B. C.	230	29.87	30.12	+ .07	57.6	− 2.4	64.8	50.5	76	48	0.15	−0.25	0.0
Barkerville, B. C.	4,180												
Triangle Island, B. C.	680												
Prince Rupert, B. C.	170												
Hamilton, Ber.	151	30.10	30.26	+ .12	77.9	− 0.8	83.9	71.9	88	67	1.50	−2.94	0.0

LATE REPORTS.

TABLE 2.—*Data furnished by the Canadian Meteorological Service, June, 1921.*

Stations.	Altitude above mean sea level, Jan. 1, 1919.	Pressure.			Temperature of the air.						Precipitation.		
		Station reduced to mean of 24 hours.	Sea level reduced to mean of 24 hours.	Departure from normal.	Mean max. + mean min. ÷2.	Departure from normal.	Mean maximum.	Mean minimum.	Highest.	Lowest.	Total.	Departure from normal.	Total snowfall.
	Feet.	*Inches.*	*Inches.*	*Inches.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	*Inches.*	*Inches.*	*Inches.*
Medicine Hat, Alb.	2,144	27.55	29.78	−0.07	69.7	+ 7.7	84.4	55.0	96	47	1.40	−1.36	0.0
Banff, Alb.	4,521	25.34	29.83	− .01	55.5	+ 4.0	68.9	42.1	79	32	1.26	−2.07	0.0
Edmonton, Alb.	2,150	27.56	29.81	− .03	60.0	+ 3.1	73.8	46.3	82	33	3.08	+0.22	0.0
Barkerville, B. C.	4,180	25.62	29.89	− .02	49.7	− 1.0	61.2	38.1	71	30	3.49	+0.01	0.0
Hamilton, Ber.	151	29.89	30.05	− .05	72.7	− 2.3	77.8	67.6	82	63	2.59	−3.36	0.0

SEISMOLOGICAL REPORTS FOR JULY, 1921.

W. J. HUMPHREYS, Professor in Charge.

[Weather Bureau, Washington, Sept. 3, 1921.]

TABLE 1.—*Noninstrumental earthquake reports, July, 1921.*

Day.	Approximate time, Greenwich civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-Forel.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
		CALIFORNIA.								
1921.	H. m.		° ′	° ′			M. s.			
July 21	20 30	Susanville	40 30	120 45	4	3			Light shocks on several days	Associated Press.
25	5 05	Campbell	37 14	121 53	3	1		None	Felt by several	F. M. Righter.
	5 15	Centerville	37 30	122 00	2	1		Faint	Felt by few	M. L. Mowry.
	5 05	Idria	36 24	120 42	2	1		None	Felt by several	A. J. Martin.
		Los Gatos	37 12	121 58	3	1		do	do	F. H. McCullagh.
		do	37 12	121 58	3	1		do	Motion, N-S	I. H. Snyder.
		Salinas	36 36	121 40	3	1	7	do	Felt by many	Dr. E. D. Eddy.
	5 06	San Francisco	37 48	122 26	2-3	2	5, 10	do	Felt throughout city	G. H. Willson.
	5 ca	San Jose	37 15	121 53	3	Several.		do	Felt by several	U. S. Weather Bureau.
	5 09	do	37 15	121 53	3					L. J. Kroeck.
	5 05	Santa Clara	37 15	121 54	3	1		None	Felt by many	Associated Press.
	5 10	Spreckels	36 38	121 36	5	2	Few.	do		W. J. Hartung.
	5 04	Watsonville	36 50	121 30	4	1	21	Rumbling	Felt by many	J. Hansen.
	5 05	Wrights	34 03	118 15	3	1		None	Felt by several	A. Postma.
		COLORADO.								
27	21 30	Garfield	38 40	106 20	2	1	10	Loud	do	L. N. Felton.
29	2 55	do	38 40	106 20	2	1	3	Faint	do	Do.
		NEW MEXICO.								
31	3 55	Senorito	36 00	107 00	4	1	4-5	Rumbling	Felt by many	J. Curry.

TABLE 2.—*Instrumental Reports, July, 1921.*

[For significance of symbols and abbreviations, and for a description of stations and instruments, see the REVIEW for January, 1921, p. 47.]

ARIZONA. *U. S. C. & G. S. Magnetic Observatory, Tucson.*

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1921.			H. m. s.	Sec.	μ	μ	Km.	
July 12		P	20 06 26					
		L	20 07 26	5				
		M_E	20 07 38		20			
		M_N	20 08 06			30		
		C_E	20 07 58					
		C_N	20 08 23					
		F_E	20 16					
		F_N	20 21					

CALIFORNIA. *Theosophical University, Point Loma.*

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1921.			H. m. s.	Sec.	μ	μ	Km.	
July 25					100	100		Tremors.
30					100	100		

DISTRICT OF COLUMBIA. *U. S. Weather Bureau, Washington.*

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1921.			H. m. s.	Sec.	μ	μ	Km.	
July 8		e	10 56 30					
		L	11 01 ..					
		F	11 10 ..					
9		e	7 10 ..					
		F	7 14 ..					

HAWAII. *U. S. C. & G. S. Magnetic Observatory, Honolulu.*

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1921.			H. m. s.	Sec.	μ	μ	Km.	
July 3		P	5 17 10					
		L_E	5 21 13	18				
		L_N	5 21 30	12				
		M_E	5 22 37	11	*1,600			
		M_N	5 23 46	10		*1,200		
		C_E	5 22 52					
		C_N	5 29 20					
		F_E	5 32 ..					
		F_N	5 41 ..					
4								
		PR1	14 35 16	10				Difficult to analyze.
		i_N	14 37 12	10				
		S_N	14 40 11	22				
		L_E	14 47 47	22				
		M_E	14 50 07	20	*1,300			
		M_N	14 41 26	20		*1,300		
		F_E	14 56 ..					
		F_N	14 49 ..					
7		P_E	11 06 00	11				
		S_E	11 08 20					
		L_E	11 09 20	20				
		L_N	11 08 50	18				
		M_E	11 21 05	18	*1,900			
		M_N	11 19 09	17		*1,200		
		F_E	11 55 ..					
		F_N	11 45 ..					
10		e_E	2.07 55					
		e_N	2 07 22					
		S_E	2 11 23	18				
		S_N	2 10 43	12				
		L_E	2 15 25	20				
		L_N	2 16 20	20				
		M_E	2 20 10	17	*1,000			
		M_N	2 20 14	16		*700		
		F_E	2 43 ..					
		F_N	2 26 ..					

* Trace amplitude.

TABLE 2.—*Instrumental Reports, July, 1921*—Continued.

HAWAII. *U. S. C. & G. S. Magnetic Observatory, Honolulu*—Con.

1921.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
July 10		e_E	7 03 ..	19				Nothing definite.
		F_E	7 18 ..					
13		e_E	11 24 ..	18				Do.
		e_N	11 30 ..	19				
		F	11 37 ..					
13		e_E	13 23 40					
		L_E	13 31 35	24				
		L_N	13 32 30					
		M_E	13 35 03	20	* 500			
		F_E	13 45 ..					
		F_N	13 41 ..					
15		i_N	18 27 24	10				Nothing definite on NS after first impulse.
		e_E	18 42 33	22				
		L_E	18 45 50	20				
		M_E	18 48 40	14	* 400			
		F_E	18 53 ..					
		F_N	18 50 ..					
23		L_N	8 57 30	24				No record on EW component.
		M_N	9 00 35	20	* 500			
		C_N	9 03 40	18				
		F_N	9 30 ..	12				
26		P	10 52 38					P doubtful; en may be L.
		e_N	10 59 21	10				
		L_E	11 01 32	12				
		M_E	11 02 45		* 300			
		M_N	11 01 58			* 500		
		C_E	11 03 15					
		F_E	11 12 ..					
		F_N	11 05 ..					
29		P	0 42 27					P and S not well defined.
		S	0 45 02	15				
		L_E	0 46 30	19				
		L_N	0 45 57	30				
		M_E	0 47 10	20	*1,100			
		M_N	0 47 31	25		*1,500		
		C_E	0 50 ..					
		C_N	0 53 52	19				
		F_E	1 01 ..					
		F_N	1 09 ..	18				
31		iP	10 06 48	14			2,700	
		S_E	10 11 00					
		S_N	10 11 18	19				
		L	10 13 10	28				
		M_E	10 16 23	21	*1,500			
		M_N	10 15 46	23		*1,400		
		C_E	10 27 50	15				
		C_N	10 23 11	17				
		F_E	10 52 ..	18				
		F_N	10 54 ..	15				
31		e	23 46 42					
		M_E	23 48 55	11	*800			
		M_N	23 48 50	10		*600		
		C	23 50 00					
		F_E	24 07 ..					
		F_N	24 04 ..					

ILLINOIS. *U. S. Weather Bureau, Chicago.*

1921.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
July 4		iP	14 41 51				5,500	
		i	14 42 49					
		PRi	14 44 15					
		S	14 49 15					
		L?	14 58 15					
		F	15 30 *ca.*					
7		e	10 57 05					
		eL	11 12 07					
		L	11 41 ..	18				Very regular.
		L	12 04 ..	15				
		F	13 10 *ca.*					
8		P?	10 54 07				2,600	
		S	10 58 17					
		L	11 00 40					
		F	11 40 *ca.*					
9		e	7 01 50					
		L	7 02 40					
		F	7 20 *ca.*					
10		eL	2 43 ..	18				Regular.
		F	3 30 *ca.*					
12		e	20 17 50					Phases indistinguishable.
		F	20 30 *ca.*					
13		P?	10 43 00				3,900	
		S	10 48 40					
		eL	10 58 ..					
		L	11 18 ..	18				Regular.
		F	11 40 *ca.*					

* Trace amplitude.

ILLINOIS. *U. S. Weather Bureau, Chicago*—Continued.

1921.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
July 13		e	13 51 ..					
		eL	14 01 30	22				Regular.
		F	14 40 *ca.*					
21		e	20 25 ..					May not be seismic.
		F	20 40 ..					
29		P?	0 52 43					
		S?	1 00 30					
		eL	1 14 ..	26				
		F	2 10 *ca.*					
31		e	10 19 23					
		eL	10 42 ..					
		L	10 45 ..	22				Regular.
		L	10 56 ..	18				
		F						Lost in next quake.
31		e	11 38 ..					
		eL	11 57 ..					
		L	12 02 ..	22				
		L	12 12 ..	18				
		F	12 40 *ca.*					

CANADA. *Dominion Observatory, Ottawa.*

1921.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
July 4		i	14 42 11					
		i	14 42 48					
		e	14 44 48					
		$eL_E?$	14 55 ..					
		L_E	14 59 ..					
		L_E	15 04 ..	22				
		F	15 30 ..					
7		e_N	10 57 07					
		eL_E	11 11 00					
		L_E	11 16 ..	10				
		L_E	11 27 ..	21				
		L_E	11 38 ..	16				
		L_E	11 51 30	19				
		L_E	12 02 30	17				
		L_E	12 13 ..	15				
		F	12 40 ..					
8		e_N	10 54 27					
		e_{NE}	10 58 50					
		eL_E	11 02 38					
		L	11 03 30	12				
		F	11 25 ..					
9		e?	7 13 12					
		eL_E	7 14 ..					
		L_E	7 15 ..	11				
		F	7 20 *ca.*					
10		$e?_E$	2 46 12					
		L_E	2 52 ..	20				
		L_E	3 05 ..	20				
		F	3 25 *ca.*					
12		e	20 22 17					
		e	20 23 21					
		eL	20 25 24					
		L_E	20 27 ..	8				
		F	20 35 ..					
13		e?	(10 42)..					
		eL_E	10 56 30					
		L_E	11 01 ..					
		L_E	11 08 ..	19				
		F	11 35 *ca.*					
24		e(P)	21 17 30					May be P and S as shown; if so, O is 21:10:34, and distance 3,700 km. Press reports Calif. quake.
		e	21 18 15					
		i(S)	21 23 00					
		eL?	21 26 30					
		F	21 45 ..					
25		e	19 07 21					
		e	19 12 45					
		e	19 22 24					
		eL?	19 34 ..					
		F	19 50 *ca.*					
25		e	19 57 30					
		e	20 01 42					
		eL_E	20 17 ..					
		L_E	20 24 ..					
		F	20 47 ..					
31		$e?_E$	10 21 ..					
		$e?_E$	10 28 ..					
		eLe	10 50 ..	23				
		L_E	10 55 30	19				
		L_E	11 01 ..	17				
		L_E	11 35 30	17				
		L_E	12 00 ..	19				
		F	12 08 *ca.*					

TABLE 2.—*Instrumental Reports, July, 1921*—Continued.

CANADA. *Dominion Meteorological Service, Toronto.*

1921.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
July 3		L	? 6 02 42					
		M	? 6 03 24		*100			
		F	? 6 11 48					
4		L	? 9 47 00		*50			
		F						
7		L	?11 33 42					Heavy micros.
		L	?11 38 06					
13		e?	11 11 42					Micros.
		L	11 22 36		*100			
		L	11 38 06					
13		L	13 36 24					Micros.
		L	13 45 48		*300?			
		L	13 54 42					
25		L?	19 09 24					Micros.
		eL	19 16 54		*200			
		L	19 37 36					
25		L	19 59 12					
		M	19 59 30		*300			
		iL	20 17 54					
29		e?	1 04 18					
		i	1 18 00					
		e	1 22 18					
		i	1 24 00					
		eL	1 26 42					
		M	1 30 48		*400			
		eL	1 38 30					
		eL	1 47 30					
		F	1 51 00					
31		e	10 22 30					
		e	10 32 54					
		L	?10 52 36					
		eL	10 56 36					
		M	11 03 00		*500			Faint trace.
		F	?12 12 36					

* Trace amplitude.

CANADA. *Dominion Meteorological Service, Victoria.*

1921.			*H. m. s.*	*Sec.*	μ	μ	*Km.*
July 3		L	5 40 26				
		M	5 44 22		*200		
		F	5 50 16				
4		L	14 38 04				
		M	14 40 31		*250		
		F	15 09 33				
7		L	11 26 35				
		M	11 31 00		*250		
		F	12 05 56				
13		L	11 24 52				
		M	11 30 16		*250		
		F	11 36 50				
13		P	13 36 10				
		L	13 48 48				
		M	13 53 23		*600		
		F	14 05 12				
29		?P	0 50 49				
		?S	0 55 15				
		L	1 01 39				
		M	1 06 59		*250		2,640?
		F	1 26 14				
31		P	10 09 01				
		S	10 15 25				
		L	10 27 42				
		M	10 36 04		*500		4,670
		F	11 01 39				

* Trace amplitude.

No earthquakes were recorded during July, 1921, at the following stations:

COLORADO. *Regis College*, Denver.
MISSOURI. *St. Louis University*, St. Louis (station closed July 27, 3 p. m. to July 29, 3 p. m.).
CANAL ZONE. *Panama Canal*, Balboa Heights.
VERMONT. *U. S. Weather Bureau*, Northfield.

Reports for July, 1921, have not been received from the following stations:

ALABAMA. *Spring Hill College*, Mobile.
ALASKA. *U. S. C. & G. S. Magnetic Observatory*, Sitka.
DISTRICT OF COLUMBIA. *Georgetown University*, Washington.
MARYLAND. *U. S. C. & G. S. Magnetic Observatory*, Cheltenham.
MASSACHUSETTS. *Harvard University*, Cambridge.
NEW YORK. *Canisius College*, Buffalo; *Cornell University*, Ithaca.
PORTO RICO. *U. S. C. & G. S. Magnetic Observatory*, Vieques.

The following station was not in operation during July, 1921:

NEW YORK. *Fordham University*, New York.

Late Reports.

DISTRICT OF COLUMBIA. *Georgetown University*, Washington.

1921.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
June 4		e_N	1 45 ..					Heavy micros.
		F	2 50 ..					
15		e_N	19 03 ..					EW does not show.
		eL_N?	19 06 36					
		F	19 25 ..					
17		e_E	8 26 ..					e may possibly be S. Difficult.
		e_N	8 25 55					
		L_E	8 29 33	7–8				
		F	8 45 ..					
17		e_E	10 35 ..					Heavy micros.
		e_N	10 34 58					
		eL_N?	10 37 30					
		F	10 50 ..					
25		e_E	2 15 52					Heavy micros.
		e_N	2 15 52					
		eL_E	2 25 12					
		eL_N	2 25 00					
		L_E	2 28 44	10				
		L_N	2 28 00	14				
		F	2 54 ..					
28		eL_E?	14 10 00					Sheets put on at 14*h.* 8*m.*; quake then on apparently.
		eL_N?	14 10 36	19				
		F	15 *ca.* ..					

NEW YORK. *Cornell University*, Ithaca.

1921.			*H. m. s.*	*Sec.*	μ	μ	*Km.*
May 1		eP	5 46 15	5			
		eS	5 50 42				
		eL	5 56 30				
		L_E	6 00 10	13			
		F	6 43 ..				
14		eL	21 23 30	17			
		F	21 53 ..				
14		eP	21 17 ..	3			
		eL	22 27 42	4			
		L_N	22 30 23	7			
		F	22 48 ..				
28		e	21 10 30	4			
		eL	21 12 29	4			
		F	21 28 ..				
June 17		e	8 26 ..				
		F	8 40 ..				
25		e	2 24 48	5			
		L	2 28 25	13			
		F	2 46 ..				

TABLE 2.—*Instrumental Reports, July, 1921*—Continued.

CANADA. *Dominion Meteorological Service, Toronto.*

1921.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
June 4		L	1 22 36					
		M	1 22 48		*100			
		F						Micros.
14		M	9 24 54		*200			May not be seismic.
		F	9 28 24					
17		L	10 30 54					
		M	10 31 06		*100			
		F	10 55 54					
25		e?	2 17 00					Micros.
		eL	2 24 00					
		eL	2 26 24					
		M	2 27 18		*200			
		F						Micros.
28		e	14 37 00					Heavy micros, or spider.
		e	14 40 00					
		L	14 54 00					
		L	15 04 48					
30		P	2 15 54					
		S	2 20 42					
		iL	2 28 30					
		M	2 28 54		*400		3,070	
		F						

* Trace amplitude.

CANADA. *Dominion Meteorological Service, Victoria.*

1921.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
June 4		P	1 25 55					
		M	1 27 24		*250			
		F	1 31 19					
14		L	9 21 35					
		M	9 25 08		*200			
		F	9 31 02					
17		eL	8 19 10					
		M	8 20 38		*300			
		F	8 24 34					
17		L	10 28 30					Times doubtful.
		F	10 32 30		*100			
25		L	2 05 28				840	
		M	2 07 26		*500			
		F	2 13 50					
28		P	14 16 33				6,860	
		S	14 24 55					
		L	14 35 44					
		M	14 50 29		*250			
		F	15 10 10					

* Trace amplitude.

Chart I. Hydrographs of Several Principal Rivers, July, 1921.

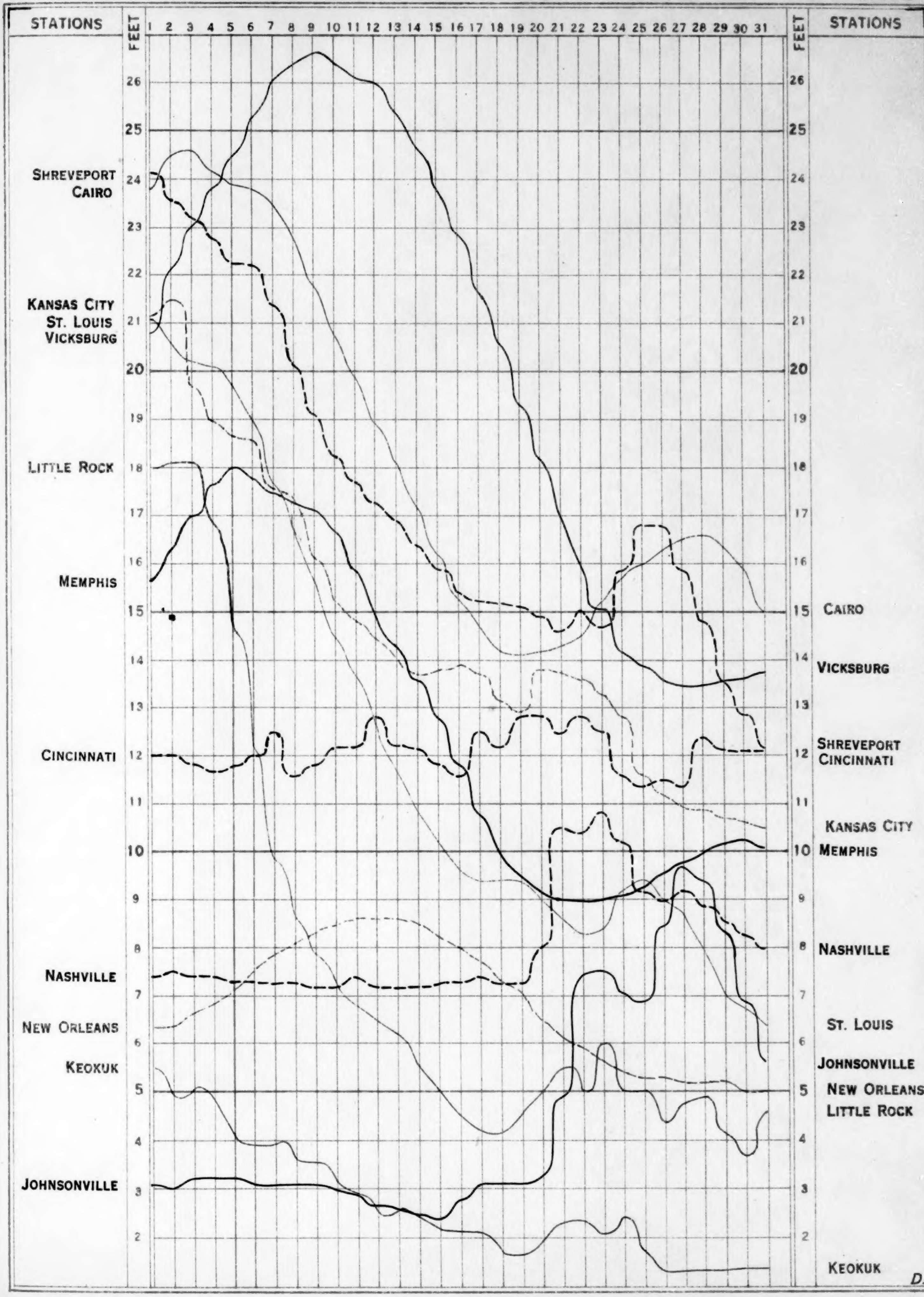


Chart II. Tracks of Centers of High Areas, July, 1921.

(Plotted by Wilfred P. Day.)

Chart III. Tracks of Centers of Low Areas, July, 1921.

(Plotted by Wilfred P. Day.)

Chart III. Tracks of Centers of Low Areas, July, 1921.
(Plotted by Wilfred P. Day.)

Chart IV. Departure (°F.) of the Mean Temperature from the Normal, July, 1921.

Chart V. Total Precipitation, Inches, July, 1921.

Chart VI. Percentage of Clear Sky between Sunrise and Sunset, July, 1921.

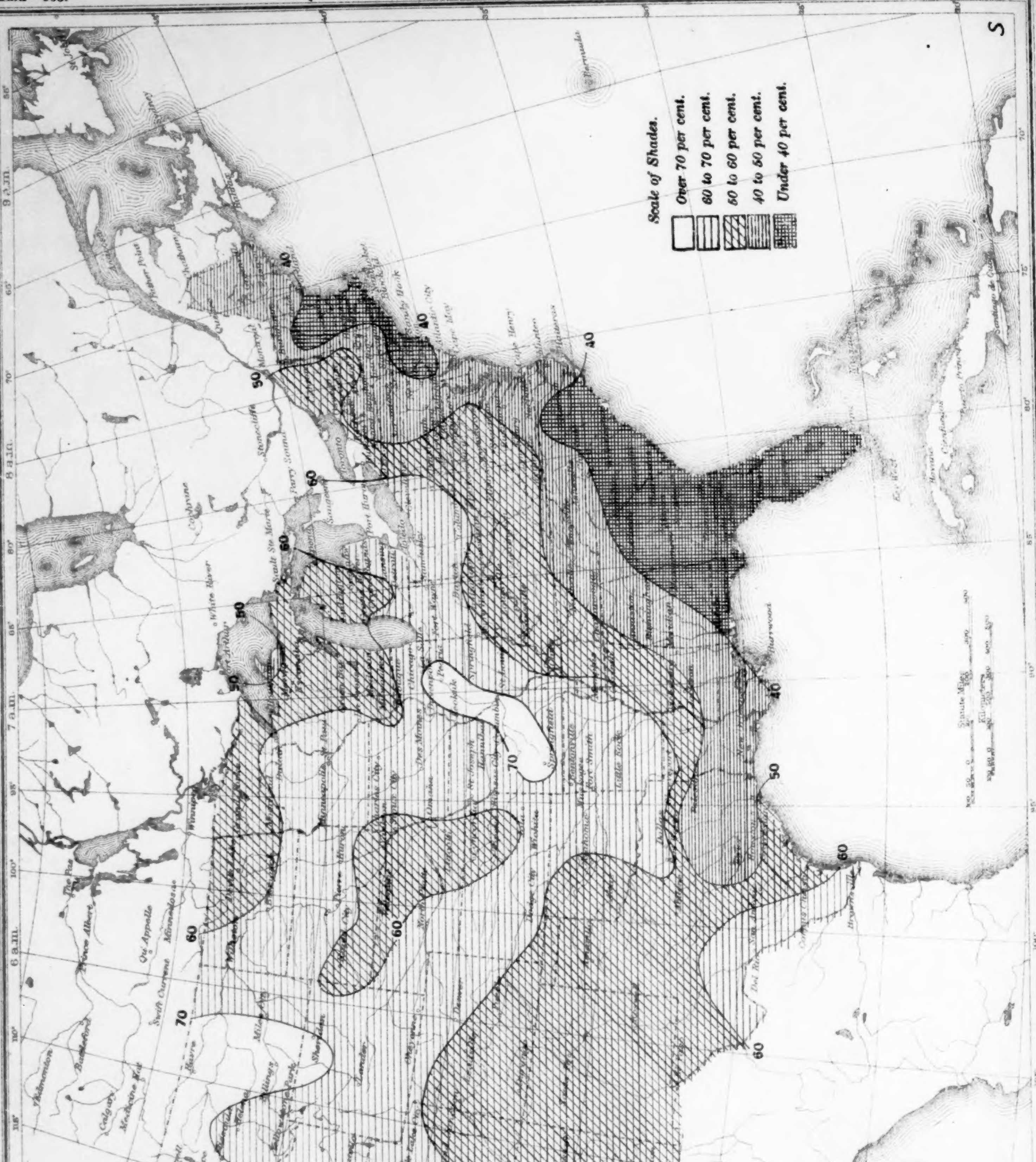


Chart VII. Isobars at Sea-level and Isotherms at Surface; Prevailing Winds, July, 1921.

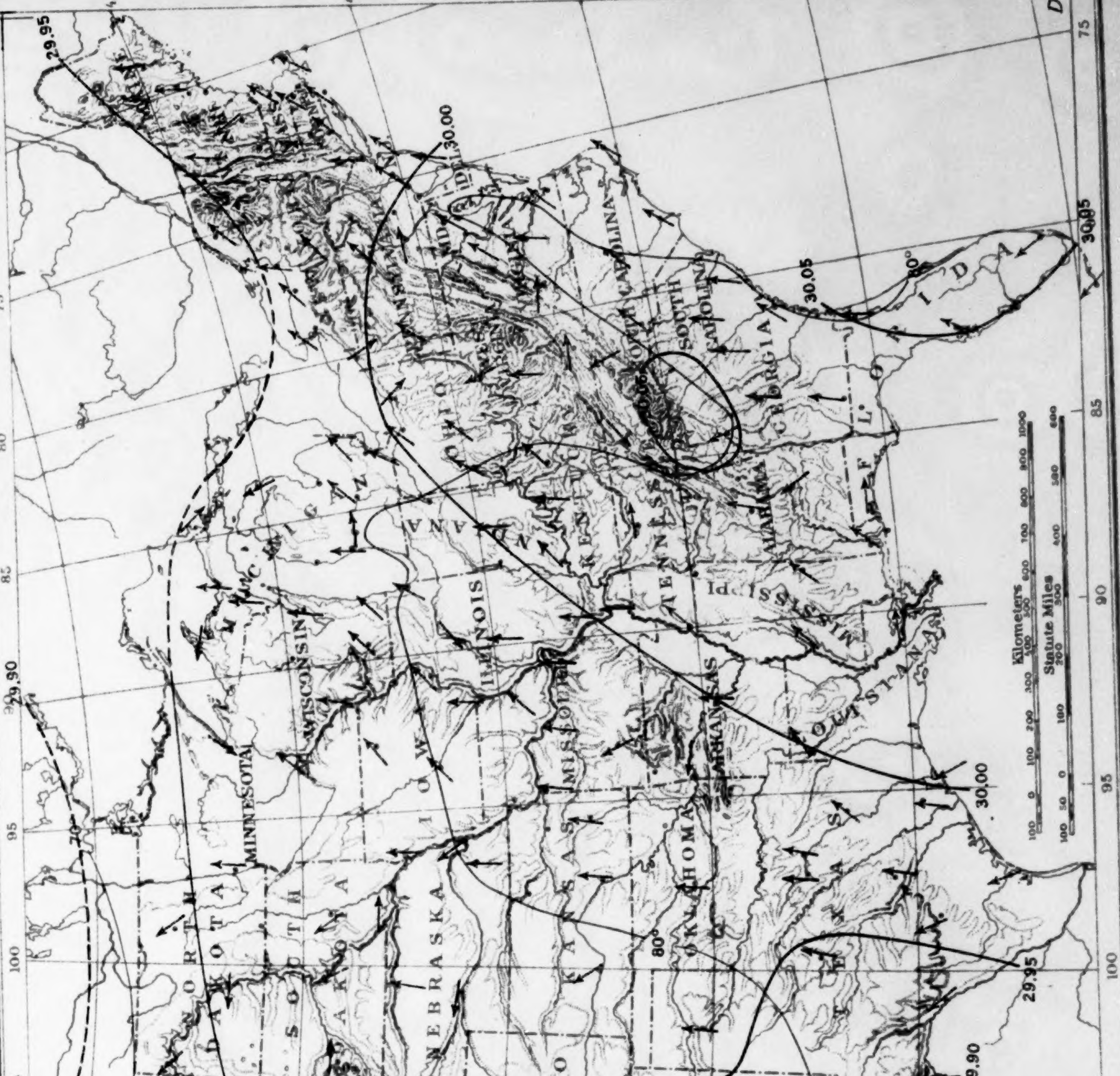


Chart VIII. Percentage of Normal Precipitation, March 1 to July 31, 1921.

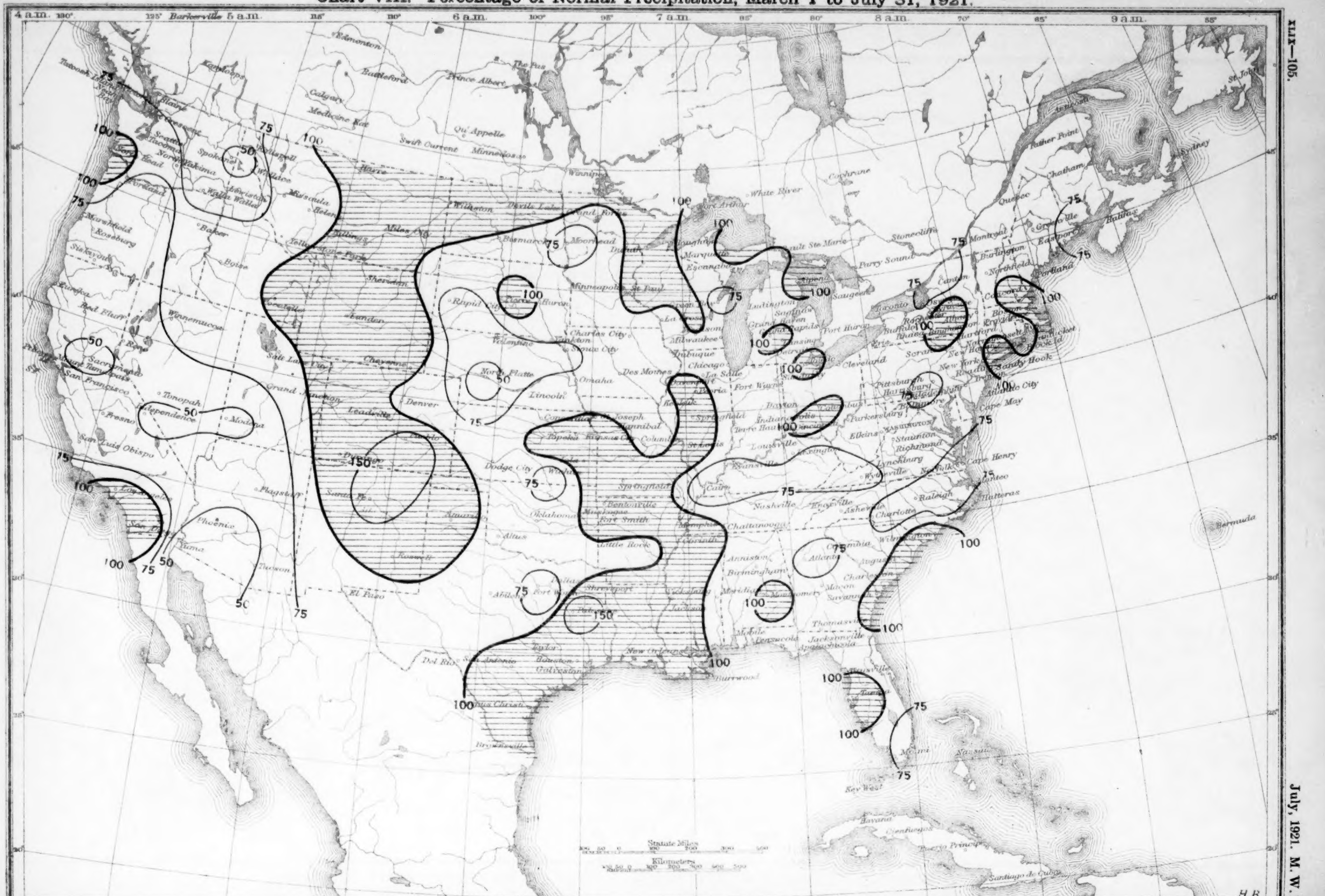


Chart IX. Weather Map of North Atlantic Ocean, July 24, 1921.

Chart IX. Weather Map of North Atlantic Ocean, July 24, 1921.

(Plotted by F. A. Young.)

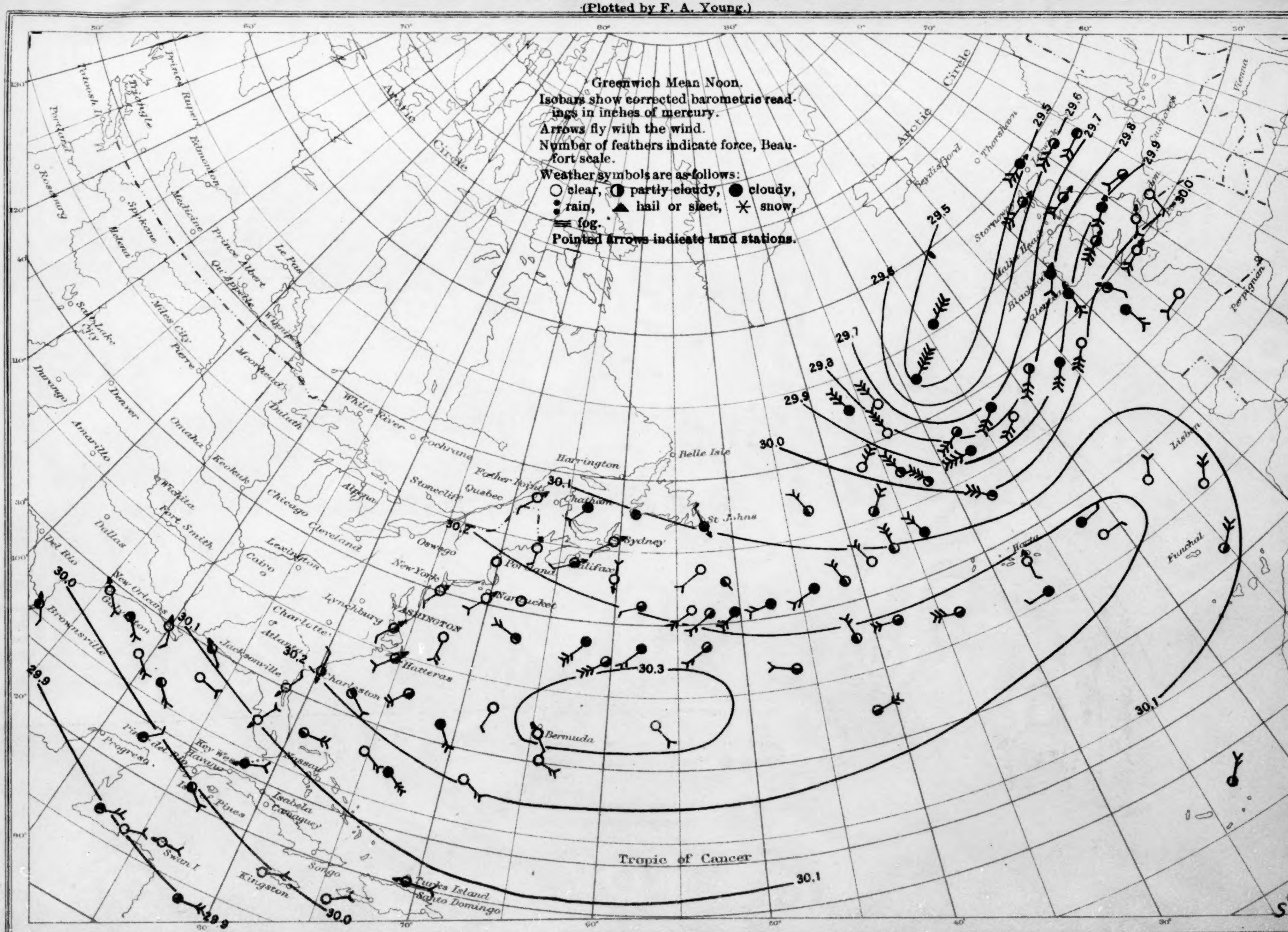
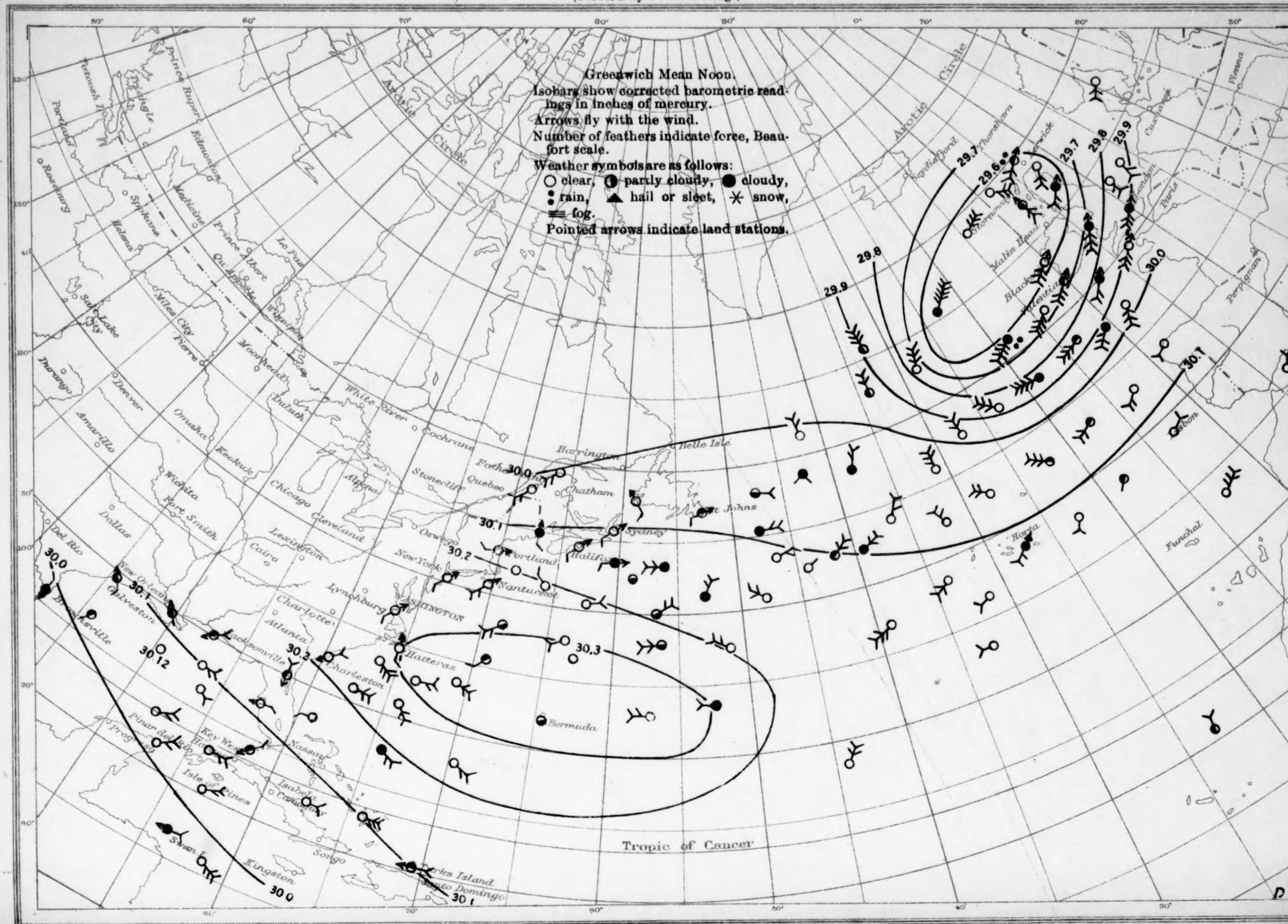


Chart X. Weather Map of North Atlantic Ocean, July 25, 1921.

(Plotted by F. A. Young.)



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JULY, 1921.

CONTENTS.

CORRIGENDA.

REVIEW, May, 1921:

Page 287, first column, second paragraph from bottom should read: If a, figure 3, represents a value of $0.00066 \times 760(t-t')$, b the value 760, b' the value B, then a'=0.00066 B$(t-t')$=0.00066×760 B$(t-t')$/760, since $a':b'::a:b$, or $a'=ab'/b$.

Same page, in figure 3, a and a' should be interchanged. In the legend to this figure $c-c'$ should be $e-e'$.